Juvenile Salmonid Monitoring in Battle Creek, California, October 2003 through September 2004

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Prepared by:

Kellie S. Whitton
Jess M. Newton
Matthew R. Brown

U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
10950 Tyler Road
Red Bluff, CA 96080

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Juvenile Salmonid Monitoring in Battle Creek, California, October 2003 through September 2004

Kellie S. Whitton, Jess M. Newton, and Matthew R. Brown

U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office
10959 Tyler Road, Red Bluff, CA 96080, (530)527-3043

Abstract- In October 2003, the U.S. Fish and Wildlife Service continued an ongoing juvenile salmonid monitoring project on Battle Creek, California, using rotary screw traps. Battle Creek, a tributary of the Sacramento River, is important to the conservation and recovery of federally listed anadromous salmonids in the Sacramento River watershed because of its unique hydrology, geology, and habitat suitability for several anadromous species. Information about juvenile salmonid abundance and migration in Battle Creek is necessary to guide efforts at maintaining and eventually restoring populations of threatened and endangered anadromous salmonids. From October 2003 through September 2004 four runs of Chinook salmon *Oncorhynchus tshawytscha*, rainbow trout/steelhead *Oncorhynchus mykiss*, and 19 species of non-salmonids were captured in either the Lower (LBC) or Upper Battle Creek (UBC) rotary screw traps. To determine rotary screw-trap efficiency, we conducted 13 mark-recapture trials at the LBC trap and 16 at the UBC trap, during January 14 through April 16, 2004. Individual and pooled valid trap efficiencies ranged from 0.043 to 0.127 at LBC and 0.021 to 0.109 at UBC. Chinook salmon run designations were made using length-at-date criteria developed for the Sacramento River, which resulted in underestimates of spring and overestimates of fall Chinook salmon production at both traps. The brood year 2003 spring and fall Chinook salmon passage estimates at the LBC trap were 14,809 and 3,143,957 respectively. The brood year 2004 late-fall Chinook salmon passage estimate at the LBC trap was 23,193. The annual passage of winter Chinook salmon was not estimated for the lower trap because they were likely using Battle Creek for non-natal rearing. The passage estimate for age 1+ rainbow trout/steelhead at the LBC trap was 471 and 1,144 for brood year 2004 young-of-the-year. Brood year 2003 spring Chinook salmon passage at the UBC trap was 11,264. The brood year 2003 fall Chinook salmon passage estimate at the upper trap was 141,393. The brood year 2004 late-fall Chinook salmon passage estimate at the UBC trap was 1,145. Passage estimates were not made for winter Chinook salmon at the upper trap as catch rates (n=1) were too low. The passage estimate for age 1+ rainbow trout/steelhead at the upper trap was 826 and 2,770 for brood year 2004 young-of-the-year. A decrease in adult fall Chinook salmon escapement and improved flows and temperatures appears to have increased spawning success because the annual passage estimate at the LBC trap was significantly higher than observed in 2001 when adult escapement was approximately 400,000 compared to the estimated 64,764 in 2002. At the UBC trap increased adult escapement and improved flows and temperatures may explain increases observed in spring and fall Chinook salmon annual passage estimates at the UBC trap. Decreases in late-fall Chinook salmon and rainbow trout/steelhead annual JPIs at both traps may be explained by decreases in adult escapement and high flow events which occurred in mid to late February.

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Introduction

In recent decades, California has experienced declines in several of its wild salmon and steelhead populations. These declines have been linked to a variety of factors, but the development of federal, state, municipal, and private water projects is likely a primary contributing factor (Jones and Stokes 2005). As a result of the declines, two populations of Chinook salmon (*Oncorhynchus tshawytscha*) and one population of steelhead (*O. mykiss*) in the Sacramento River watershed have been listed as threatened or endangered under the Endangered Species Act (ESA) or the California Endangered Species Act (CESA).

Battle Creek, a tributary of the Sacramento River, is important to the conservation and recovery of federally listed anadromous salmonids in the Sacramento River watershed because of its unique hydrology, geology, and habitat suitability for several anadromous species and historical land uses (Jones and Stokes 2005). Restoration actions and projects that are planned or have begun in Battle Creek focus on providing habitat for the endangered Sacramento River winter Chinook salmon, the threatened Central Valley spring Chinook salmon, and the threatened Central Valley steelhead. Currently the geographic range of the winter Chinook salmon Evolutionary Significant Unit is small and limited to the mainstem of the Sacramento River between Keswick Dam and the town of Red Bluff, California, where it may be susceptible to catastrophic loss. Establishing a second population in Battle Creek could reduce the likelihood of extinction. Battle Creek also has the potential to support significant, self-sustaining populations of spring Chinook salmon and steelhead.

Since the early 1900's, a hydroelectric project comprised of several dams, canals, and powerhouses has operated in the Battle Creek watershed. The hydroelectric project, which is currently owned by Pacific Gas and Electric Company (PG&E), has had severe impacts upon anadromous salmonids and their habitat (Ward and Kier 1999), including a reduction of instream flows, barriers to migration, loss of habitat, flow related temperature impacts, etc.

In 1992, the Central Valley Project Improvement Act (CVPIA), federally legislated efforts to double populations of Central Valley anadromous salmonids. The CVPIA Anadromous Fisheries Restoration Program outlined actions to restore Battle Creek, which included increasing flows past PG&E's hydroelectric power diversions to provide adequate holding, spawning, and rearing habitat for anadromous salmonids (USFWS 1997). Prior to 2001, PG&E was required under its Federal Energy Regulatory Commission (FERC) license to provide minimum instream flows of 0.08 m^3/s (3 cfs) downstream of diversions on North Fork Battle Creek and 0.14 m^3/s (5 cfs) downstream of diversions on South Fork Battle Creek. However, from 1995 to 2001, the CVPIA Water Acquisition Program contracted with PG&E to increase minimum stream flow in the lower reaches of the north and south forks of Battle Creek. This initial flow augmentation provided flows between 0.71 and 0.99 m^3/s (25 and 35 cfs) below Eagle Canyon Dam on the north fork and below Coleman Diversion Dam on the south fork.

In 1999, PG&E, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and National Marine Fisheries Service (NMFS) signed a Memorandum of Understanding (MOU) to formalize the agreement regarding the Battle Creek Chinook Salmon and Steelhead Restoration Project (Restoration Project). The planning, designing, and permitting phases of the Restoration Project have taken longer than originally anticipated; therefore, funds for increased minimum flows in North and South Fork Battle Creek from the CVPIA Water Acquisition Program ran out in 2001. However, the federal and State of California interagency program known as the CALFED Bay-Delta Program (CALFED) funded the Battle Creek Interim Flow Project beginning in 2001 and will continue to until the Restoration Project begins. The intent of the Interim Flow Project (IFP) is to provide immediate habitat improvement in the lower reaches of Battle Creek to sustain current natural populations while implementation of the more comprehensive Restoration Project moves forward. Under the IFP, PG&E would maintain minimum instream flows at 0.85 m^3/s (30 cfs) by reducing their hydroelectric power diversions from May to October. In 2001, funding for the IFP was provided for the north fork, but not the south fork. In 2002, some of the north fork IFP flows were reallocated to the south fork under an agreement which allows for changing flows on either of the forks based on environmental conditions (i.e., water temperatures, numbers and locations of live Chinook salmon and redds). Beginning in late 2002, the IFP began providing the full minimum flow of 0.85 m^3/s (30 cfs) on both forks. In 2001, increased flows were provided only on the north fork in part based on observations of higher Chinook salmon spawning on the north fork than on the south fork. Redd counts from 1995 to 1998 indicated that 39% of spawning occurred in the north fork versus 23% in the south fork (J. M. Newton, USFWS, RBFWO, unpublished data).

The U.S. Fish and Wildlife Services' Red Bluff Fish and Wildlife Office (RBFWO) began using rotary screw traps to monitor juvenile salmonids on Battle Creek, Shasta and Tehama Counties, California, in September 1998 (Whitton et al. 2006). The purpose of this report is to summarize data collected during the period October 1, 2003 through September 30, 2004. This ongoing monitoring project has three primary objectives: (1) determine an annual juvenile passage index (JPI) for Chinook salmon (salmon) and rainbow trout/steelhead (trout), for inter-year comparisons; (2) obtain juvenile salmonid life history information including size, condition, emergence, emigration timing, and potential factors limiting survival at various life stages, and (3) collect tissue samples for genetic analyses.

Study Area

Battle Creek and its tributaries drain the western volcanic slopes of Mount Lassen in the southern Cascade Range. The creek has two primary tributaries, North Fork Battle Creek which originates near Mt. Huckleberry and South Fork Battle Creek which originates in Battle Creek Meadows south of the town of Mineral, California. North Fork Battle Creek is approximately 47.5 km (29.5 miles) long from the headwaters to the confluence and has a natural barrier waterfall located 21.7 km (rm 13.5) from the confluence (Jones and Stokes 2004). South Fork Battle Creek is approximately 45 km (28 miles) long and has a natural barrier waterfall (Angel Falls) located 30.4 km (rm 18.9) from the confluence (Jones and Stokes 2004). The mainstem portion of Battle Creek flows approximately 27.3 km (17 miles) west from the confluence of the two forks to the Sacramento River east of Cottonwood, California. The entire watershed encompasses an area of approximately 93,200 ha (360 $miles^2$; Jones and Stokes 2004). The current 39 km (24.4 miles) of anadromous fishery in Battle Creek encompasses that portion of the creek from the Eagle Canyon Dam on North Fork Battle Creek and Coleman Dam on South Fork Battle Creek to its confluence with the Sacramento River (Figure 1). Historically, the anadromous fishery exceeded 85 km (53 miles).

Battle Creek has the highest base flows of any of the Sacramento River tributaries between Keswick Dam and the Feather River, and flows are influenced by both precipitation and spring flow from basalt formations (Jones and Stokes 2005). The average flow in Battle Creek is approximately 14.1 m^3/s (500 cfs; Jones and Stokes 2004). South Fork Battle Creek is more influenced by precipitation and likely experiences higher peak flows, whereas North Fork Battle Creek receives more of its water from snow melt and spring-fed tributaries. Maximum discharge usually occurs from November to April as a result of heavy precipitation. Average annual precipitation in the watershed ranges from about 64 cm (25 inches) at the Coleman Powerhouse to more than 127 cm (50 inches) at the headwaters, with most precipitation occurring between November and April (Ward and Kier 1999). Ambient air temperatures range from about 0ºC (32ºF) in the winter to summer highs in excess of 46ºC (115ºF).

Land ownership in the Battle Creek watershed is a combination of state, federal, and private including the CDFG, Bureau of Land Management (BLM), and USFWS. Most of the land within the restoration area is private and zoned for agriculture, including grazing. Currently, much of the lower Battle Creek watershed is undeveloped, with scattered private residences, ranching enterprises, and local entities.

The Red Bluff Fish and Wildlife Office installed and operated two rotary screw traps on Battle Creek, the first site was located 4.5 km (rm 2.8) upstream of the confluence with the Sacramento River, and the second site was located 9.5 km (rm 5.9) upstream of the confluence (Figure 1). The lower trap site was designated Lower Battle Creek (LBC) and the upper trap site was designated Upper Battle Creek (UBC). The stream substrate at these locations is primarily composed of gravel and cobble, and the riparian zone vegetation is dominated by California sycamore (*Plantanus racemosa*), alder (Alnus spp.), Valley Oak (*Quercus lobata*), Himalayan blackberry (*Rubus discolor)*, California wild grape (*Vitis Californica*) and other native and non-native species.

Methods

Trap Operation

In October 2003, the Red Bluff Fish and Wildlife Office continued the operation of two rotary screw traps on Battle Creek. During the current reporting period (October 1, 2003 through September 30, 2004), the Lower Battle Creek trap (LBC) was operated from October 1, 2003 through August 2, 2004 while the Upper Battle Creek trap (UBC) was operated from October 1, 2003 through September 30, 2004. September 30, 2004 was designated the end of the current reporting period as it allowed us to estimate total passage for brood year 2003 (BY03) fall and spring Chinook salmon and total catch for BY03 winter Chinook salmon at the LBC trap. Although the designated reporting period does not include the total passage of brood year 2004 (BY04) late-fall Chinook salmon, complete passage estimates are reported as the data were available and it will prevent duplication in the 2004-2005 report.

The rotary screw traps, manufactured by E.G. Solutions® in Corvallis, Oregon, consist of a 1.5-m diameter cone covered with 3-mm diameter perforated stainless steel screen. The cone, which acts as a sieve separating fish and debris from the water flowing through the trap, rotates in an auger-type action passing water, fish, and debris to the rear of the trap and directly into an aluminum live box. The live box retains fish and debris, and passes water through screens located in the back, sides, and bottom. The cone and live box are supported between two pontoons. Two 30 to 46-cm diameter trees on opposite banks of the creek were used as anchor points for securing each trap in the creek, and a system of cables, ropes and pulleys was used to position the traps in the thalweg.

We attempted to operate the traps 24 h per day; 7 d each week, but at times high flows, hatchery releases, and other miscellaneous problems limited our ability to operate the traps continuously (Appendices 1 and 2). In addition, when few or no salmonids were captured, we did not operate the LBC trap (August 2 to September 30, 2004). Traps were not operated when stream flows exceeded certain levels in order to prevent fish mortality, damage to equipment, and to ensure crew safety. The traps were checked once per day unless high flows, heavy debris loads, or high fish densities required multiple trap checks to avoid mortality of captured fish or damage to equipment. In addition, to improve the accuracy of our juvenile passage indexes (JPI's), we attempted to fish high flows when most juvenile salmonids are thought to outmigrate and increase the number of mark-recapture trials, which were used to estimate trap efficiency. When flows allowed, the crews were able to access the traps by wading from the stream bank; however, during high flows access to the traps required that the crews use the cable and pulley system to pull the traps into shallow water. After or during sampling and maintenance, the traps were repositioned in the thalweg.

In October 2000 the LBC trap was modified by placing an aluminum plate over one of the two existing cone discharge ports and removing an exterior cone hatch cover (half-cone modification). As a result, half of the collected fish and debris were not discharged into the live box, but rather were discharged from the cone back into the creek. This effectively reduced our catch of both fish and debris by half, and also reduced crowding of fish in the live box by half. During the 2003 to 2004 reporting period, the LBC trap was operated with the half-cone modification from December 20 to 23, 2003, January 31 to February 2, 2004, February 21 to 25, 2004, and April 19 to May 4, 2004 In previous years, additional modifications were made to the traps and daily operations to reduce the potential for impacts to captured fish and to improve our efficiency. Modifications to traps included increasing the size of the live boxes and floatation pontoons, and adding baffles to the live boxes.

Each time a trap was sampled, crews would sample fish present in the live box, remove debris from the cone and live box, collect environmental and trap data, and complete any necessary trap repairs. Data collected at each trap included, dates and times of trap operation, water depth at the trap site, cone fishing depth, number of cone rotations during the sample period, cone rotation time, amount and type of debris removed from the live box, basic weather conditions, water temperature, water velocity entering the cone, and turbidity. Water depths were measured to the nearest 0.03 m (0.1 feet) using a graduated staff. The cone fishing depth was measured with a gauge permanently mounted to the trap frame in front of the cone. The number of rotations of the RST cone was measured with a mechanical stroke counter (Reddington Counters, Inc., Windsor, CT) that was mounted to the trap railing adjacent to the cone. The amount of debris in the live box was volumetrically measured using a 44.0 liter (10-gallon) plastic tub. Water temperatures were continuously measured with an instream Onset Optic Stow Away® temperature data logger. Water velocity was measured as the average velocity from a grab-sample using an Oceanic® Model 2030 flowmeter (General Oceanics, Inc., Miami, Florida). The average velocity was measured for a minimum of 3 min while the live box was being cleared of debris. Water turbidity was measured from a grab-sample with a Hach® Model 2100 turbidity meter (Hach Company, Ames, Iowa). In addition, daily stream discharge data collected by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) was also used for trap operations and to compare discharge and downstream migration patterns. The gauge site is located below the Coleman Fish Hatchery barrier weir and approximately 0.2 km downstream of the UBC trap (Figure 1).

Biological Sampling

Juvenile sampling at the traps was conducted using standardized techniques that were generally consistent with the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) standard protocol (CVPIA 1997). Dip nets were used to transfer fish and debris from the live box to a sorting table for examination. Each day the trap was sampled, a minimum number of each fish taxa captured were counted and then depending on the species, either fork length (FL) or total length (TL) was measured. Mortalities were also counted and measured.

Live fish to be measured were placed in a 3.8-L (1-gallon) plastic tub and anesthetized with a tricaine methanesulfonate (MS-222; Argent Chemical Laboratories, Inc. Redmond, Washington) solution at a concentration of 60 to 80 mg/L. After being measured, fish were placed in a 37.8-L (10-gallon) plastic tub filled with fresh water to allow for recovery before being released back into the creek. Water in the tubs was replaced as necessary to maintain adequate temperature and oxygen levels. Catch data for all fish taxa were typically summarized as either weekly totals for salmonids or season totals for non-salmonids. Due to the large numbers of juvenile salmon that were frequently encountered and project objectives, different criteria were used to sample salmon, trout, and non-salmonid species.

Chinook salmon.—When less than approximately 250 salmon were captured in the trap all salmon were counted and measured for FL (to the nearest 1 mm). The measured juvenile salmon were also assigned a life-stage classification of yolk-sac fry (C0), fry (C1), parr (C2), silvery parr (C3), or smolt (C4), and a run designation of fall, late-fall, winter, or spring. Life-stage classification was based on morphological features and run designations were based on length-at-date criteria from Greene (1992). Length data for all Chinook salmon runs was combined for graphical purposes as the length-at date criteria developed for the mainstem Sacramento River may not be directly applicable to the tributary populations.

When more than approximately 250 juvenile salmon were captured, subsampling was conducted. All salmon in the subsample were identified, counted, and measured. These salmon were also assigned a life-stage classification and run designation, using the methods described above. All other salmon were counted and identified. A cylinder-shaped net with 3-mm mesh and a split-bottom construction was used for subsampling. The bottom of the subsampling net was constructed with a metal frame that created two equal halves. A closed mesh bag was sewed onto one half of the frame and an open mesh bag was sewed onto the other half of the frame. The subsampling net was placed in a 117-L (30-gallon) bucket that was partially filled with creek water. All captured juvenile salmon were poured into the bucket. Once the fish had distributed evenly throughout the bucket, the net was lifted and approximately half of the salmon were retained in the side of the net with the closed mesh bag, and approximately half of the salmon in the side with the open mesh bag were retained in the bucket. We continued to successively subsample (split) until approximately 150 to 250 individuals remained in a subsample. The number of successive splits that we used varied with the number of salmon collected. Subsampling was used to obtain a representative sample for measuring. To determine total catch, we counted all salmon in each split. Chinook salmon biological data were summarized by brood year for each run designation.

Rainbow trout/steelhead.—Due to the smaller numbers encountered, all rainbow trout/steelhead captured in the traps were counted and FL measured to the nearest 1 mm. Life stages of juvenile trout were classified similarly as salmon, as requested by the Interagency Ecological Program (IEP) Steelhead Project Work Team. All live rainbow trout/steelhead >50 mm captured at both traps were weighed to the nearest 0.1 g for CDFG's Stream Evaluation Program.

Non-salmonid taxa.—All non-salmonid taxa that were captured were counted, but we only measured up to approximately 30 randomly selected individuals of each taxa. Total length was measured for lamprey *Lampetra spp.,* sculpin *Cottus spp.*, and western mosquitofish (*Gambusia affinis*); otherwise, FL was measured for all other non-salmonid taxa. Non-salmonids were not the focus of this monitoring project; therefore, only total catch by species is provided in this report but length data was collected.

Trap Efficiency and Juvenile Salmonid Passage

One of the goals of our monitoring project was to estimate the number of juvenile salmonids passing downstream in a given unit of time, usually a week and brood year. We defined this estimate as the juvenile passage index (JPI). Since each trap only captures fish from a small portion of the creek cross section, we used trap efficiencies, which were determined using mark-recaptured methods, and the actual catch to estimate the weekly and annual JPI. For days when the trap was not fishing, daily catch was estimated by averaging an equal number of days before and after the days not fished. For example, if the trap did not fish for 2 d, the daily catch for those days was estimated by averaging catch from 2 d before and 2 d after the period the trap did not fish. However, if one of the days before or after was also a missed day, it was usually not used to estimate other missed days. For example, if the trap did not fish for 3 d, but one of the 3 days before was also a missed day, then catch from the 2 d before and 3 d after the missed period were used to estimate catch.

During the current reporting period, late-fall Chinook salmon released by the Coleman National Fish Hatchery (CNFH) in November and December 2003 and January 2004 were all marked with an adipose fin-clip; therefore, when they were captured in the trap, they were subtracted from the daily catch. However, in April 2004 no fall Chinook salmon released upstream of the LBC trap by CNFH were marked; therefore, from April 20 to mid-June when they were likely to be captured in the LBC trap, most Chinook salmon >45 mm were classified as hatchery fish and were not included in the daily count.

Mark-recapture trials.— Mark-recapture trials were conducted to estimate trap efficiency. Ideally, separate mark-recapture trials should be conducted for each species, run, and life-stage to estimate species and age-specific trap efficiencies. However, catch rates for steelhead, spring, winter, and late-fall Chinook salmon were too low to conduct separate trials; therefore, trap efficiencies were estimated using primarily fall Chinook salmon fry, but late-fall Chinook fry and larger fish were used for a few trials. We attempted to use only naturally-produced (unmarked, unclipped, and untagged) juvenile salmon for mark-recapture trials. However, when trap catches were insufficient in March and April, some hatchery fish that were captured in the LBC trap were used for mark-recapture trials. Marked Chinook salmon that were recaptured in the traps were counted, measured, and subsequently released downstream of the trap to prevent them from being recaptured again.

During the 2003 to 2004 season, two marks were used during all but one trial conducted at the LBC trap (Table 2). To apply the first mark, juvenile salmon were anesthetized with an MS-222 solution at a concentration of 60 to 80 mg/L. Once anesthetized, we applied lower-caudal fin-clips using scissors to remove a small portion of the lower-caudal fin. After the salmon had recovered, they were placed in a live-car and immersed in Bismark brown-Y stain (J. T. Baker Chemical Company, Phillipsburg, New Jersey) for 50 min at a concentration of 8 g/380 L of water (211 mg/L). When air temperatures were high in late spring, a portable water chiller unit was used to maintain ambient stream temperatures and reduce stress and mortality during the staining process. During the first trial only one mark (Bismark brown) was used. All salmon marked for LBC trials were released at the Jelly's Ferry Bridge which is located approximately 1.3 km (0.8 mi) upstream of the trap (Figure 1). Trials conducted at the UBC trap were done using methods similar to those used for the LBC trap. During 15 of the 16 trials conducted at the UBC trap, an upper-caudal fin-clip was applied to allow field crews to differentiate between fish released for trials at the LBC trap (Table 3; lower-caudal fin-clip). Only one mark (Bismark brown) was used during the last trial at the UBC trap. All salmon marked for UBC trials were released at the Coleman National Fish Hatchery's Intake 3 located 1.6 km (1.0 mi) upstream of the UBC trap (Figure 1). Although not presented in this report, we measured the fork length of about 30 to 50 marked salmon prior to release, and then measured all of the recaptured salmon to make comparisons between marked fish released and marked fish recaptured. Marked fish were generally held overnight and released the next day. Prior to release, mortalities and injured fish were removed and the remaining fish were counted and released. During most trials, marked fish were released after dark or at dusk to reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated during transportation, and to simulate natural populations of outmigrating Chinook salmon which move downstream primarily at night (Healey 1998; J. T. Earley, USFWS, RBFWO, unpublished data).

Trap efficiency.—Trap efficiency was estimated using a stratified Bailey's estimator, which is a modification of the standard Lincoln-Peterson estimator (Bailey 1951; Steinhorst et al. 2004). The Bailey's estimator was used as it performs better with small sample sizes and is not undefined when there are zero recaptures (Carlson et al. 1998; Steinhorst et al. 2004). In addition, Steinhorst et al. (2004) found it to be the least biased of three estimators. Trap efficiency was estimated by

$$\hat{E}_h = \frac{(r_h + 1)}{(m_h + 1)}, \tag{1}$$

where m_h is the number of marked fish released in week h and r_h is the number of marked fish recaptured in week h. Although trap efficiency was calculated for all mark-recapture trials, only those trials with at least seven recaptures were used as suggested by Steinhorst et al. (2004). Occasionally if a mark-recapture trial had less than seven recaptures, but the estimated trap efficiency and the mean weekly stream flows were similar to adjacent week(s), the number of marks and recaptures were pooled prior to estimating trap efficiency. Otherwise, a season average efficiency was used to estimate the JPI during weeks where there were less than seven recaptures or during weeks when no mark-recapture trials were conducted. The season average efficiency was based on all trials with more than seven recaptures, unless there were trials that had been pooled, in which case the pooled results were used when calculating the season average efficiency. If two mark-recapture trials were conducted during the same week, the results were combined to calculate the average weekly trap efficiency. A half-cone modification was used at the LBC trap for several days during the reporting period. However, only two mark-recapture trials were conducted while the trap was modified and neither trial had sufficient recaptures (n=7) to be considered valid; therefore, the number of recaptures for those trials and catch for days when the trap was operated with the half-cone modification were doubled to make them equivalent to trials and catch for weeks when the trap was operated at full cone.

Juvenile passage index (JPI).— Weekly JPI estimates for Chinook salmon and rainbow trout/steelhead were calculated using weekly catch totals and either the weekly trap efficiency, pooled trap efficiency, or average season trap efficiency. Juvenile Chinook salmon JPI's at LBC and UBC were summarized by brood year where the weekly catch for each run of Chinook salmon included all life-stages from a single brood year. Rainbow trout/ steelhead were summarized as either young-of-the-year (yoy) or age 1+, which included individuals from all other age classes The fork length distribution (fork length by date) of rainbow trout/steelhead captured in either trap was used to determine weekly catch of young-of-the-year and age 1+. With few exceptions, graphical display of fork length distribution indicated a distinct separation of the two groups. In addition, age 1+ and young-of-the-year rainbow trout/steelhead captured during the same week could usually be distinguished by their life-stage classification.

The season was stratified by week because as Steinhorst et al. (2004) found, combining the data where there are likely changes in trap efficiency throughout the season leads to biased estimates. Using methods described by Carlson et al. (1998) and Steinhorst et al. (2004), the weekly JPI's were estimated by

$$\hat{N}_h = \frac{U_h}{\hat{E}_h}, \tag{2}$$

where U_h is the unmarked catch during week *h*. The total JPI for the year is then estimated by

$$\hat{N} = \sum_{h=1}^{L} \hat{N}_h \tag{3}$$

where *L* is the total number of weeks. Variance and the 90 and 95% confidence intervals for $\hat{N}_h$ each week were determined by the percentile bootstrap method with 1,000 iterations (Efron and Tibshirani 1986; Buckland and Garthwaite 1991; Thedinga et al. 1994; Steinhorst et al. 2004). Using simulated data with known numbers of migrants, and trap efficiencies, Steinhorst et al. (2004) determined the percentile bootstrap method for developing confidence intervals performed the best, as it had the best coverage of a 95% confidence interval. Each bootstrap iteration involved first drawing 1,000 r^*_{hj} (j=1,2,…,1000; asterisk indicates bootstrap simulated values) from the binomial distribution (m_h, $\hat{E}_h$)(Carlson et al. 1998) and then calculating 1,000 $\hat{N}^*_{hj}$ using equations (1) and (2), replacing r_h with r^*_{hj}. The 1,000 bootstrap iterations of the total JPI ($\hat{N}^*_j$) were calculated as

$$\hat{N}^*_j = \sum_{h=1}^{L} \hat{N}^*_{hj} . \tag{4}$$

As described by Steinhorst et al. (2004), the 95% confidence intervals for the weekly and total JPI's were found by ordering the 1,000 $\hat{N}^*_{hj}$ or $\hat{N}^*_j$ and locating the 25th and 975th values. Similarly, the 90% confidence intervals for the weekly and total JPI's were found by locating the 50th and 950th values of the ordered iterations. Ordering was not performed until after the $\hat{N}^*_j$ were derived. The variances for $\hat{N}_h$ and $\hat{N}$ were calculated as the standard sample variances of the 1,000 $\hat{N}^*_{hj}$ and $\hat{N}^*_j$, respectively (Buckland and Garthwaite 1991).

Results

Trap Operation

Lower Battle Creek (LBC).— During the current reporting period, the LBC trap was operated continuously from October 1, 2003 to August 2, 2004, except during high flows, hatchery releases, and when the trap was being repaired (Appendix 1). Of the 366 d available during the reporting period (October 1, 2003 through September 30, 2004), the trap was operated 279 d. No sampling due to few or no salmonids accounted for 59 of the missed sample days (68%), high flows accounted for 13 d (15%), hatchery releases accounted for 10 d (11%), and trap repair accounted for the remaining 5 d (6%). Monthly sampling effort from October 2003 through August 2004 varied from a low of 7% in August to a high of 100% during 5 months (Figure 2). The trap was not operated from August 3 to September 30, 2004 because sampling from previous years has shown that little or no salmonid outmigration occurs during that time (Whitton et al. 2006; Whitton et al. 2007a).

Mean daily water temperatures at the LBC trap varied from a low of 5.6ºC (42.0ºF) on December 23, 2003 to a high of 21.3ºC (70.3ºF) on July 6 and 23, 2004 (Figure 3). Mean daily flow that was measured by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) varied from lows of 5.6 m^3/s (196 cfs) in early September 2004 to a peak mean daily flow of 115 m^3/s (4,060 cfs) on February 17, 2004 (4,060 cfs; Figure 3). A maximum flow of 150.6 m^3/s (5,320cfs) also occurred at the LBC trap on February 17, 2004. Turbidity at the LBC trap varied from a low of 0.9 NTU's on November 28, 2003 and August 2, 2004 to a peak of 16.2 NTU's on December 5, 2003 (Figure 3). In general, turbidity increased with increasing flows, but increases in turbidity did not always appear to be related to similar increases in flow (Figure 3). However, turbidity was only measured when the trap was operating; therefore, it is likely that turbidity was higher during the high flow events.

Upper Battle Creek (UBC).— During the current reporting period, the UBC trap was operated continuously from October 1, 2003 to September 30, 2004, except during high flows and one day when the cone was not rotating due to debris (Appendix 2). Of the 366 d available, the trap was operated approximately 354 d. High flows accounted for 11 of the missed sample days (92%) and debris was responsible for the remaining missed day (8 %). The monthly sampling effort varied from a low of 79% in February to a high of 100% during 7 months (Figure 2, Appendix 2).

Mean daily water temperatures at the UBC trap varied from a low of 5.6ºC (42.0ºF) on December 29, 2003 to a high of 19.9ºC (67.9ºF) on July 21 and 23, 2004 (Figure 4). Mean daily flows for the UBC trap are the same as those reported for LBC as the same gauging station was used (Figure 4). Turbidity at the UBC trap varied from several days <1.0 NTU's in October 2003 and July and August 2004 to a high of 35.9 NTU's on February 17, 2004 (Figure 4). In general, turbidity increased with increasing flows, but increases in turbidity did not always appear to be related to similar increases in flow (Figure 4). However, turbidity was only measured when the trap was operating; therefore, it is likely that turbidity was higher during the high flow events.

Biological Sampling

Spring Chinook salmon - LBC.—Brood year 2003 (BY03) spring Chinook salmon were first captured at the LBC trap the week of December 2, 2003 with a peak weekly catch of 693 the week of February 10, 2004 (Figure 5). The last spring Chinook salmon was captured the week of April 13, 2004. The BY03 spring Chinook salmon total catch based on the length-at-date criteria was 874. However after adjusting the total catch for days the trap was not operated, the adjusted total catch was 1,163.

Fork lengths of spring Chinook salmon sampled at the LBC trap varied from 34 to 99 mm with a mean of 78 mm (N=189; Figure 6). Length frequency data for all runs were combined because run designations were determined using length-at-date-criteria developed for the Sacramento River (Green 1992; Figure 7). In Battle Creek, there is overlap in fork lengths between runs, but the overlap appears to be a particular problem with spring and fall Chinook salmon. The life-stage composition of spring Chinook salmon captured at the LBC trap was 7.4% fry, 4.2.% parr, 52.9% silvery parr, and 35.5% smolt (Table 1).

Fall Chinook salmon - LBC.—Fall Chinook salmon were the most abundant salmonid captured at the LBC trap. Brood year 2003 fall Chinook salmon were first captured at the trap the week of November 25, 2003 (Figure 5). Following their initial capture, the numbers of fall Chinook salmon increased rapidly to a peak weekly capture of 56,916 the week of February 10, 2004. A second smaller peak weekly catch of 564 occurred the week of April 27, 2004. The total number of BY03 fall Chinook salmon captured in the LBC trap on days that it was operated was 171,947. After adjusting the total catch reported above for days the trap was not operated, the adjusted total catch of BY03 fall Chinook salmon at the LBC trap was 206,266.

Fall Chinook salmon fork lengths ranged from 22 to 109 mm during the reporting period, with a mean fork length of 38 mm (N=16,007; Figure 6). Length frequency data for all runs were combined because run designation was determined by length-at-date-criteria developed for the Sacramento River (Green 1992; Figure 7). Length frequency histograms for Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (91%; Figure 7). Fall Chinook salmon fry comprised the largest portion of these fish as they were the most abundant run captured at the LBC trap. The life-stage composition of fall Chinook salmon captured at the LBC trap was 14.4% yolk-sac fry, 76.1% fry, 7.1% parr, 2.7% silvery parr, and 0.3% smolt (Table 1).

Late-fall Chinook salmon - LBC.— Individuals from two brood years of late-fall Chinook salmon (BY03 and BY04) were captured at the LBC trap between October 1, 2003 and September 30, 2004; however, only 38 BY03 late-fall Chinook salmon were captured in the trap during the reporting period (Figure 5). Brood year 2003 late-fall Chinook salmon weekly and annual passage estimates were reported in the 2002-2003 report (Whitton et al. 2007b). Brood year 2004 late-fall Chinook salmon were first captured in the trap the week of March 30, 2004 with a peak weekly capture of 467 the week of May 18, 2004 (Figure 5). The last week of capture was December 28, 2004. Data from the next reporting period (October 1 to December 24, 2004) was used to allow complete reporting of BY04 late-fall Chinook salmon catch and passage estimates. Using length-at-date criteria, the actual catch of BY04 late-fall Chinook salmon in the LBC trap was 1,403. After adjusting total catch for days the trap was not operated, the adjusted total catch of BY04 late-fall Chinook salmon was 1,457.

Fork lengths of late-fall Chinook salmon captured at the LBC trap varied from 30 to 125 mm with a mean fork length of 38 mm (N=1,308; Figure 6). Length frequency histograms which included all runs of Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 7). The life-stage composition of late-fall Chinook salmon sampled at the LBC trap was 10.8% yolk sac fry, 77.9% fry, 7.0% parr, 3.4% silvery parr, and 0.9% smolt (Table 1).

Winter Chinook salmon - LBC.—Winter Chinook salmon were first captured at the LBC trap the week of October 14, 2003 with the peak weekly catch of 293 occurring the week of February 10, 2004. The last day winter Chinook were captured at the trap was April 8, 2004. Winter Chinook are likely migrants from the Sacramento River using lower Battle Creek for non-natal rearing. The total catch based on the length-at-date criteria was 776. However after adjusting the total catch for days the trap was not operated, the adjusted total catch was 899.

Fork lengths of winter Chinook salmon sampled at the LBC trap varied from 37 to 115 mm with a mean of 65 mm (N=159; Figure 6). Fork length frequency data for winter Chinook salmon was combined with other runs for graphical display (Figure 7). The life-stage composition of winter Chinook salmon sampled at the trap was 0.6% fry, 22.6% parr, 64.8% silvery parr, and 12.0% smolt (Table 1). Winter Chinook salmon use lower Battle Creek for non-natal rearing which likely accounts for the limited presence of the fry life-stage.

Rainbow trout/steelhead - LBC.— Rainbow trout/steelhead were first captured at the LBC trap the week of October 21, 2003 with a peak weekly capture of 10 occurring the week of April

20, 2004 (Figure 8). The actual rainbow trout total catch at the LBC trap was 80; however, after adjusting the total catch for days the trap was not operated, the adjusted total catch was 94.

Fork lengths of young-of-the-year (yoy) rainbow trout/steelhead ranged from 26 to 110 mm with a mean of 49 and a median of 40 mm (N=51; Figures 9 and 10). The range in fork lengths of yoy trout accounts for growth over time. Fork lengths of age 1+ trout ranged from 63 to 340 mm with a mean and median of 177 mm and 190 mm, respectively (N=19; Figure 9 & 10). The length frequency histogram for trout was skewed towards newly emerging fry ≤30 mm (37.7%) as seen in previous years, but a similar percentage of trout were 45 to 90 mm in length (36.2%; Figure 10). Rainbow trout/steelhead parr (40.0%), fry (22.9%), and silvery parr (17.1%) were the most abundant life-stages sampled at the LBC trap, while yolk-sac fry and smolt were the least abundant (12.9 and 7.1%; Table 1).

Non salmonids - LBC.—From October 1, 2003 through August 2, 2004, 12 native non-salmonid species were sampled at the LBC trap including, California roach *Hesperoleucus symmetricus* (N=9), speckled dace *Rhinicthys osculus* (N=57), hitch *Lavinia exilicauda* (N=65), hardhead *Mylopharodon conocephalus* (N=464), Pacific lamprey *Lampetra tridentata* (N=231), prickly sculpin *Cottus asper* (N=10), riffle sculpin *Cottus gulosus* (N=317), river lamprey *Lampetra ayresi* (N=1), Sacramento pikeminnow *Ptychocheilus grandis* (N=84), Sacramento sucker *Catostomus occidentalis* (N=428), tule perch *Hysterocarpus traski* (N=194), and threespine stickleback *Gasterosteus* aculeatus (N=5). In addition, seven introduced non-salmonids were also captured in the LBC trap including, channel catfish *Ictalurus punctatus* (N=1), green sunfish *Lepomis cyanellus* (N=40), largemouth bass *Micropterus salmoides* (N=91), pumpkinseed *Lepomis gibbosus* (N=5), small mouth bass *Micropterus dolomieu* (N=1), spotted bass *Micropterus punctultus* (N=3), and western mosquitofish *Gambusia affinis* (N=6). Next to Chinook salmon, hardheads and Sacramento suckers were the next most abundant species captured in the traps. In addition, several unidentified cottid, cyprinid, centrarcid, lamprey, and centrachid fry were also captured in the trap.

Spring Chinook salmon - UBC.— Brood year 2003 spring Chinook salmon were first captured at the UBC trap the week of November 25, 2003 with a peak weekly catch of 90 the week of December 9, 2003 (Figure 11). A second peak catch of 69 occurred the week of April 13, 2004. The last BY03 spring Chinook salmon was captured the week of May 11, 2004. The BY03 spring Chinook salmon total catch based on the length-at-date criteria was 422. However after adjusting the total catch for days the trap was not operated, the adjusted total catch was 456.

The fork length of spring Chinook salmon sampled at the trap varied from 33 to 110 mm with a mean fork length of 71 (N=416; Figures 12 and 13). Length frequency for all runs was combined because run designation was determined by the length-at-date-criteria developed for the Sacramento River, and there is overlap between runs, particularly between spring and fall Chinook salmon (Green 1992; Figure 13). The life-stage composition of spring Chinook salmon sampled at the UBC trap was 0.7% yolk sac fry, 26.5% fry, 6.5% parr, 26.3% silvery parr, and 40.0% smolt (Table 1).

Fall Chinook salmon - UBC.—Fall Chinook salmon were the most abundant salmonid captured at the UBC trap. Brood year 2003 fall Chinook salmon were first captured in the trap the week of November 25, 2003 with the peak weekly catch of 2,420 occurring the week of January 27, 2004 (Figure 11). Following their initial capture, the numbers of fall Chinook salmon increased rapidly and were captured every week until the week of June 8, 2004 (Figure 11). The total number of BY03 fall Chinook salmon captured in the UBC trap on days that it was operated was 10,742. After adjusting the total catch reported above for days the trap was not operated, the adjusted total catch of BY03 fall Chinook salmon at the UBC trap was 11,202.

Fork lengths of fall Chinook salmon sampled at the UBC trap varied from 29 to 96 mm with a mean of 38 mm (N=7,708; Figures 12 and 13). Length frequency histograms for Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (86%; Figure 13). Fall Chinook salmon fry comprised the largest portion of these fish as they were the most abundant run of Chinook salmon captured at the UBC trap. The life stage composition of fall Chinook salmon sampled at the UBC trap was 2.3% yolk-sac fry, 91.4% fry, 2.1% parr, 2.8% silvery parr, and 1.4% smolt (Table 1).

Late-fall Chinook salmon - UBC.— Individuals from two brood years of late-fall Chinook salmon (BY03 and BY04) were captured at the UBC trap between October 1, 2003 and December 31, 2004; however, only seven BY03 late-fall Chinook salmon were captured during the reporting period (Figure 11). Brood year 2003 late-fall Chinook salmon weekly and annual passage estimates were reported in the 2002-2003 report (Whitton et al. 2007b). Brood year 2004 late-fall Chinook were first captured in the trap the week of April 13, 2004 with a peak weekly capture of 21 the same week (Figure 11). The last week a BY04 late-fall Chinook salmon was captured was April 27, 2004. Data from the next reporting period (October 1 to December 31, 2004) were used to allow complete reporting of BY04 late-fall Chinook salmon catch and passage estimates; however, no additional late-fall were captured during this period. Using length-at-date criteria, the BY04 late-fall Chinook salmon total catch was 35. After adjusting the total catch for days the trap was not operated, the adjusted total catch of BY04 late-fall Chinook salmon remained 35.

Fork lengths of late-fall Chinook salmon captured at the UBC trap varied from 32 to 138 mm with a mean and median fork length of 46 and 35 mm, respectively (N=41; Figure 12). Length frequency histograms which included all runs of Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 13). During the current reporting period, the life-stage composition of BY04 late-fall Chinook salmon sampled at the UBC trap was 0% sac-fry, 85.4% fry, 2.4% parr, and 12.2% smolt (Table 1).

Winter Chinook salmon - UBC.—During the reporting period, only one winter Chinook salmon was captured in the UBC trap; therefore, no additional information will be reported for this race.

Rainbow trout/steelhead - UBC.— During the reporting period, 65 age 1+ and 194 young-of-the-year (yoy) rainbow trout/steelhead were captured at the UBC trap. They were first captured the week of November 4, 2003 with a peak weekly capture of 56 occurring the week of May 11, 2004 (Figure 14). The actual rainbow trout catch at the UBC trap was 244; however, after adjusting the total catch for days the trap was not operated, the adjusted total catch was 259.

Fork lengths of young-of-the-year (yoy) rainbow trout/steelhead ranged from 24 to 119 mm with a mean and median of 63 mm (N=194; Figures 15 and 16). The range in fork lengths of yoy trout accounts for growth over time. Fork lengths of age 1+ trout ranged from 84 to 255 mm with a mean of 157 mm and a median of 149 mm (N=50; Figures 15 and 16). The length frequency histogram for trout was not skewed towards newly emerging fry ≤30 mm (6.1%) as seen in 1999 to 2002; rather 69% of all trout captured were 41 to 90 mm in length (Figure 16). Rainbow trout/steelhead parr (77.1%) and silvery parr (12.7%) were the most abundant life-stages sampled at the UBC trap, whereas yolk-sac fry, fry and smolt were the least abundant (0.8, 7.8, and 1.6%; Table 1).

Non salmonids - UBC.— From October 1, 2003 through September 30, 2004, 10 native non-salmonid species were captured in the UBC trap, including California roach (N=2), speckled dace (N=9), hardhead (N=569), Pacific lamprey (N=662), prickly sculpin (N=3), riffle sculpin (N=202), Sacramento pikeminnow (N=115), Sacramento sucker (N=2,069), tule perch (N=35), and threespine stickleback (N=7). In addition, three introduced non-salmonid species were captured, including green sunfish (N=2), western mosquitofish (N=1), and smallmouth bass (N=1). Lamprey, cyprinid, and cottid fry were also captured at the trap, but could not be identified to species. Besides Chinook salmon, Sacramento suckers and hardheads were the next most abundant species captured in the UBC trap

Trap Efficiency and Juvenile Salmonid Passage

Lower Battle Creek trap efficiency (LBC).—To estimate trap efficiency, 13 mark-recapture trials were conducted at the LBC trap (Table 2). We marked Chinook salmon during 10 of the 42 weeks that salmonids were captured at the LBC trap (October 7, 2003 through July 20, 2004). The results of two trials were not used to calculate passage because one had no recaptures and too few fish were marked (March 12, 2004) and because the second had ≤ seven recaptures and the results could not be pooled with trials from an adjacent week (February 2, 2004). Of the 11 trials that were used to calculate passage, 10 had at least seven recaptures as recommended by Steinhorst et al. (2004). One trial with less than seven recaptures was one of two trials conducted during the same week; therefore, the results were pooled with the other trial conducted that week (January 30, 2004). However, this trial was conducted when the trap was modified for half-cone during part of the week; therefore prior to pooling it, the number of recaptures and catch during the days the trap was in half-cone status were doubled to make the results equivalent to the other trial conducted that week which occurred at full cone. During three of the weeks that trials were conducted, two separate mark-recapture trials were conducted and the results were pooled prior to calculating a weekly passage. During the remaining six weeks, only one trial was conducted. Weekly trap efficiencies for the valid pooled and unpooled trials varied from 0.043 to 0.127. Using the results of these trials, the season average efficiency was estimated at 0.063. The 2003 to 2004 season average efficiency was used to estimate passage for 34 weeks during October 1, 2003 to August 2, 2004 when no trials were conducted or when trial results were not used.

Upper Battle Creek trap efficiency (UBC).—To estimate trap efficiency, 16 mark-recapture trials were conducted at the UBC trap (Table 3). We marked Chinook salmon during 11 of the 32 weeks that salmonids were captured at the UBC trap (November 4, 2003 through June 22, 2004. The result of one trial was not used to calculate passage because too few Chinook were marked and there were less than seven recaptures (March 26, 2004). Of the 15 trials that were used to calculate passage, 12 had at least seven recaptures as recommended by Steinhorst et al. (2004). Three trials with less than seven recaptures were pooled with each other as they were conducted during adjacent weeks and efficiencies and mean flows were similar (April 2 and 9, 2003). During three of the weeks that trials were conducted, two separate mark-recapture trials were conducted and the results were pooled prior to calculating weekly passage. During all other weeks, either one or no trial was conducted. Weekly trap efficiencies for the valid pooled and unpooled trials varied from 0.021 to 0.109. Using the results of these trials, the season average efficiency was estimated at 0.078. The 2003 to 2004 UBC season average trap efficiency was used to estimate passage for 21 weeks from November 4, 2003 to June 28, 2004 when no trials were conducted or when trials results were not used.

Lower Battle Creek juvenile salmonid passage (LBC).—At the LBC trap, trap efficiency estimates were used to generate juvenile passage indexes (JPI) for spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead. Although juvenile passage indexes were calculated for spring Chinook salmon, they were underestimated because of the overlap in length with fall Chinook salmon. Juvenile passage index estimates were not calculated for winter

Chinook salmon as they are likely migrants from the Sacramento River using lower Battle Creek as non-natal rearing habitat.

The annual JPI for BY03 spring Chinook salmon was 14,809 and the 90 and 95% confidence intervals were 13,139 to 16,632 and 12,809 to 16,922 respectively (Table 4). A peak weekly passage of 7,218 occurred the week of February 10, 2004. The annual JPI for BY03 fall Chinook salmon was 3,143,959 (Table 5). The 90 and 95% confidence intervals for the annual JPI were 2,863,640 to 3,492,043 and 2,821,952 to 3,598,515, respectively. The weekly JPI's for fall Chinook salmon increased rapidly to a peak of 647,349 the week of January 27, 2004, and then began to decrease until early May when passage increased for a short time. The annual JPI for BY04 late-fall Chinook salmon was 23,193 (Table 6). The 90 and 95% confidence intervals for the annual JPI were 20,497 to 26,193 and 20,103 to 26,875, respectively. The weekly JPI's for late-fall Chinook salmon increased quickly to a peak of 7,434 the week of May 18, 2004 and then decreased to <1,000 10 weeks after the start of the outmigration; however, a few additional fish were captured sporadically until early-December. Passage estimates for BY03 late-fall Chinook salmon are not reported here because only a small portion of the run was sampled during the current reporting period. Rather, passage estimates for BY03 late-fall Chinook salmon were summarized in the 2002-2003 report (Whitton et al. 2007b). The annual JPI for yoy rainbow trout/steelhead passing the LBC trap between October 1, 2003 and September 30, 2004 was 1,144 while passage for age1+ fish was 471 (Table 7). The 90 and 95% confidence intervals for the yoy annual JPI estimate were 1,031 to 1,268 and 1,013 to 1,301, respectively. The 90 and 95% confidence intervals for the annual JPI for age 1+ fish were 421 to 526 and 413 to 538, respectively. Most age 1+ fish migrated between October and mid-May with a peak weekly passage the week of February 17, 2004. In contrast, yoy were not captured in the trap until late February with a peak weekly passage of 184 the week of March 9, 2004.

Upper Battle Creek juvenile salmonid passage (UBC).—At the UBC trap, trap efficiency estimates were used to generate juvenile passage indexes (JPI) for spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead. Although juvenile passage indexes were calculated for spring Chinook, they are underestimated because of the overlap in length with fall Chinook salmon and inaccurate due to small sample sizes. Juvenile passage indexes were not calculated for winter Chinook salmon because only one was captured in the trap.

The annual JPI for BY03 spring Chinook salmon was 11,264, and the 90 and 95% confidence intervals were 9,251 to 14,026 and 8,973 to 14,709, respectively (Table 8). A peak weekly passage of 3,174 occurred the week of April 13, 2004; however, an earlier but smaller peak of 1,151 occurred the week of December 9, 2003. These two peaks represent the initial movement of fry out in December, and then larger fish (parr, silvery parr, and smolt) in March and April. The annual JPI for BY03 fall Chinook salmon at the UBC trap was 141,393, and the 90 and 95% confidence intervals were 128,557 to 155,900 and 127,193 to 160,251, respectively (Table 9). The weekly JPI's for fall Chinook salmon increased rapidly to a peak of 26,868 the week of January 6, 2004 and then decreased until mid-March when passage began increasing slowly to a second peak (N=2,346) the week of April 13, 2004. The annual JPI for BY04 late-fall Chinook salmon was 1,145 and the 90 and 95% confidence intervals for the were 809 to 1,732 and 768 to 1,968, respectively (Table 10). Late-fall Chinook salmon were only captured at the UBC trap during 3 weeks of the reporting period. A peak weekly passage of 966 occurred the first week of passage. No additional late-fall Chinook salmon were captured from October 1 to December 31, 2004. No passage estimates were made for BY03 late-fall Chinook salmon captured at the UBC trap because only a small portion of the run was sampled during the current reporting period. Weekly and annual passage estimates for BY03 late-fall Chinook salmon at the UBC trap were summarized in the 2002 to 2003 report (Whitton et al. 2007b). The annual JPI for yoy rainbow trout/steelhead passing the UBC trap between October 1, 2003 and September 30, 2004 was 2,770 whereas passage for age1+ fish was 826 (Table 11). The 90 and 95% confidence intervals for the yoy annual JPI estimate were 2,512 to 3,057 and 2,455 to 3,142, and the 90 and 95% confidence intervals for the annual JPI for age 1+ fish were 753 to 903 and 741 to 917, respectively. Most age 1+ fish migrated during November through May, whereas yoy were not captured in the trap until early March with a peak weekly passage of 704 the week of May 11, 2004.

Discussion

Trap Operation

High flows, hatchery releases, and down time to complete trap repairs limited our ability to operate either trap continuously during the reporting period. However, during peak migration we operated the traps on a more continuous basis compared to sampling in previous years, particularly the UBC trap which operated 97% (354 d) of the season (366 d). Although there were no salmonids captured at the UBC trap after June 26, by operating the trap we were able to continue documenting the presence and abundance of non-salmonid species in upper Battle Creek and to document the relative lack of salmonids, which was especially important for winter Chinook. July through October is the primary period of winter Chinook salmon fry catch in the Sacramento River. There was a common misconception among resource management agencies that winter Chinook salmon were being produced in Battle Creek from 1999 to 2003. The LBC trap was not operated for 28 d during the primary salmonid migration period (October 1 through June 30). In addition, the trap was not operated after August 2 because sampling in previous years had shown that catch of Chinook salmon and rainbow trout/steelhead, which are the focus of our monitoring project, was very low to zero from July through October (Whitton et al. 2006; Whitton et al. 2007a). Increasing the number of days the traps operated likely increased the accuracy of our production estimates. Estimating catch on days the traps were not operated may affect our weekly and annual JPI's but the magnitude of the affect likely varies with time of year, catch, and number of consecutive days estimated. Daily catch at the UBC trap was only estimated 11 days during the sample season, and most high flow events were only 1 or 2 d. Most high flow events occurred during the peak fall and spring Chinook salmon fry outmigration period (December through February); therefore, we may have underestimated catch on days missed during high flow events because fry often disperse downstream during high flow events (Healey 1991). No high flow events occurred at either trap during the secondary peak of fall and spring Chinook salmon migration that occurs from March to May. To prevent potential mortality of naturally produced Chinook salmon from overcrowding, we did not operate the trap during hatchery releases of late-fall and fall Chinook salmon upstream of the LBC trap; therefore, we had to estimate catch for an additional 10 d in November, January, and April.

Determining whether there are better methods for estimating catch for days the traps are not operational may improve the accuracy of our passage estimates. Currently, average catch for an equal number of days before and after a period of missed sampling is used to estimate catch when the traps are not sampling. The accuracy of this method as well as others such as catch per unit volume (CPUV) or effort (CPUE) should be tested to determine whether there is a particular method that is more accurate at estimating catch during high-flow periods and other days the traps are not operated. The CPUE methodology has been used in a few other rotary screw trap studies to estimate passage during periods when traps were not operated (Griffith et al. 2001; Volkhardt et al. 2005), but comparisons with other methods did not occur.

***Recommendation**: Investigate the use of CPUV, CPUE, or other methods to estimate catch for days the trap is not fished.*

Biological Sampling

To effectively estimate passage and describe the biological characteristics of all runs of Chinook salmon on Battle Creek, the sampling methods used at the traps must be tested to ensure their applicability and accuracy. Currently, length-at-date criteria for determining run designation (Greene1992) are used on Battle Creek to differentiate runs of juvenile Chinook salmon captured in the traps. However, the criteria were developed for the mainstem Sacramento River, and are not accurate for tributary runs of Chinook salmon. There is significant size overlap between runs, particularly fall and spring Chinook salmon. This discrepancy is important when trying to accurately estimate the passage of threatened and endangered Chinook salmon. The size overlap likely resulted in underestimates of spring and overestimates of fall Chinook salmon passage at both traps. There is also overlap between fall and late-fall Chinook salmon fry in April and May. Considering the overlap between runs, genetic sampling is likely the most accurate method for assigning a run designation. However, it is expensive and will likely only be done on a portion of the total catch, which then requires the results to be extrapolated to the total catch. Also, current genetic techniques for run identification of Central Valley Chinook may need to be verified or refined for application specifically to Battle Creek populations.

Subsampling was used to obtain a representative sample of Chinook salmon for measuring and estimating the length frequency distribution, but fish size or the abundance of uncommon runs may influence the accuracy of this method. Often only a few large Chinook salmon or those classified as spring and winter Chinook salmon were captured in the traps when fry or other runs were very abundant. Run designation for Chinook salmon included in our subsample was assigned using the length-at-date criteria (Greene 1992). This information was then extrapolated to the unmeasured fish to determine total daily catch for each run. This may have been problematic with larger fish or uncommon runs (spring and winter), because if none were included in the subsample, then they were not represented in the final catch totals for that day. However, if they were included in the subsample and then extrapolated to the unmeasured catch, the catch of larger fish and uncommon runs may have been artificially inflated. Inaccuracies due to subsampling likely only occurred at the LBC trap because subsampling rarely occurred at the UBC trap because catch was almost always less than 250. In February and early March 2004, spring and winter Chinook numbers included in the LBC subsample were extrapolated to unmeasured catch, and numbers appear to be significantly higher than seen on the days immediately preceding (Figure 5). Ideally some days they would be under represented, and other days over represented resulting in an accurate overall estimate but whether this occurs has not been determined and should be investigated.

During the current reporting period the “yolk-sac fry” life stage was added for Chinook salmon captured in both traps. This change was made to distinguish salmon fry with a yolk-sac from fry without because there are likely differences in their ability to actively migrate. With the addition of yolk-sac fry, the proportion of fry decreased as fish that are classified as yolk-sac fry were included in the fry category in previous reporting periods. Life-stage composition will not be directly applicable without combining yolk-sac fry and fry in this and future years.

***Recommendation**: Develop or utilize methods such as genetics for determining the run designation of Chinook salmon captured in the traps.*

Trap Efficiency and Juvenile Salmonid Passage

Trap efficiency.—Mark-recapture methods are commonly used to estimate trap efficiency, but the results are influenced by many factors, including flow, fish size and species, release time and location, predation, type of mark, etc. In 2003 to 2004, we conducted mark-recapture trials at various flows, but no relationship was found between flow and trap efficiency at either trap. However, the number of trials conducted may not have been sufficient to show a relationship. Trap location as well as other environmental and biological factors may determine how much influence flow has on trap efficiency. Fish size can influence capture efficiency, and ideally we should have conducted separate trials for each species, run, and life stage at various seasons and flows. However, our ability to conduct age, run, and species specific trials was limited by the low abundance of fish available within each category; therefore we used fall Chinook salmon fry and parr as surrogates. The applicability of our estimates to these other groups is questionable, but Roper and Scarnecchia (1996) found that behavioral differences between hatchery and naturally produced Chinook salmon were minimal when traps were operated in higher velocities. They compared trap efficiencies when a 2.43-m (8 ft) diameter trap was rotating an average of 3.05 rotations/min, 2.37 rotations/ min, and 1.40 rotations/min. During the current reporting period, our 1.5-m (5-ft) diameter traps usually rotated an average of 3 to 11 rotations/min, unless there was algae build-up or debris plugging the cone. It seems possible that at higher velocities the benefits of increased swimming ability found in larger fish may also be smaller. Chapman and Bjornn (1969) and Everest and Chapman (1972) found that fish size was positively correlated with water velocity and depth; therefore, it is possible that trap efficiencies may be higher for larger fish because they are more likely to be found in deeper faster water where our traps are fishing. While release location and time may have influenced trap efficiency measurements; the influences of release location and time should be similar for all trials since all marked fish were released from the same location and with a few exceptions, all fish were released at dusk or after dark.

The accuracy of our passage estimates was likely impacted by our inability to conduct mark-recapture trials at certain times of the year. We only conducted mark-recapture trials from January to mid-April because insufficient numbers of naturally produced fall Chinook salmon fry and parr were available at other times of the year and fish mortality was increasing due to increasing air and water temperatures in mid-April. The influences on our weekly JPI's were likely small at certain times of the year when catch was low, but at other times it had a greater influence. For instance, the peak passage of spring Chinook salmon fry normally occurs in December, but to limit our impacts to a federally listed species we did not conduct mark-recapture trials at that time.

We used two methods for dealing with weeks when mark-recapture trials were not conducted or when recapture rates were low (<7). First, if the trap efficiency and mean weekly flow of an adjacent week or weeks were similar, we pooled the results of the mark-recapture trials. Otherwise, we used a season average efficiency based on all valid trials to estimate passage. The accuracy of our estimates was likely affected by the use of either method; however, the magnitude of the effect depends on the estimated catch at the time it was used and how different the efficiency used to estimate production (pooled or season average) was from the true trap efficiency. The influences from pooling on the annual JPI estimates at the LBC trap was likely minimal compared to using a season average efficiency, as pooling was only done for trials conducted during the same week. At the UBC trap pooling between trials from adjacent weeks was done once in addition to pooling trials conducted during the same week. Using the season average efficiency likely had more influence on the annual JPI's at both traps because it was used for all weeks when trials were not conducted. The accuracy of weekly and annual passage estimates could be in question when using this method, particularly during weeks when large numbers of Chinook salmon were passing the trap. In future sampling, release groups for mark-recapture trials should be large enough to ensure a minimum of seven recaptures. This will eliminate the need to pool data from adjacent weeks improving the accuracy of our estimates. The affects from pooling trials conducted during the same week should also be investigated. In addition, releasing larger groups of marked fish will reduce the width of our confidence intervals. In future trap operations, mark-recapture trials should be conducted for all weeks when sufficient numbers are available.

The use of hatchery fish is being explored for future sampling. If hatchery fish are available, paired trials with naturally produced Chinook salmon should be done to test whether behavioral differences exist at all sizes. Hatchery fish have been used in some studies, but Roper and Scarnecchia (1996) found that trap efficiencies for hatchery and natural Chinook salmon were different because of differences in behavior. However, they also found that efficiencies for hatchery and natural Chinook were similar for a trap operated in relatively high velocities. Differences in behavior may be small when hatchery fry are used as surrogates for naturally produced fry. The use of hatchery fry would allow us to conduct trials during the peak spring Chinook salmon outmigration when flows are more variable.

Ideally, daily mark-recapture trials provide the most accurate estimates of trap efficiency (Roper and Scarnecchia 1999), however, they are also very time intensive and expensive. However, insufficient numbers of fish were available during most of the season, but when possible two trials were conducted per week. The results of these trials were combined to estimate a weekly efficiency. This method has been used by others such as Thedinga et al. (1994). One advantage of this method is that variations in flow which may affect trap efficiency during the week are accounted for with a weekly estimate. This method also ensures that sufficient recaptures occur to meet the minimum of seven as was recommended by Steinhorst et al. (2004). As occurred with our study, mark-recapture release strategies can vary and the affects on the final estimates needs to be studied further to determine the most effective and efficient method for providing reasonable statistically-sound estimates of trap efficiency. Some studies have developed flow-trap efficiency models to allow the estimation of daily trap efficiencies (Martin et al. 2001). This method appears to be valid, but may not be applicable to all streams. The flow to trap efficiency relationship needs to be sufficiently strong to ensure that estimates of efficiency are accurate. Other variables besides flow should also be considered.

> ***Recommendation:*** *Investigate methods for conducting mark-recapture trials that will improve the accuracy of trap efficiencies such as: (a) conducting robust day and nighttime trials and applying the results to day and nighttime catch, (b) increasing the size of release groups during periods when trap efficiencies are likely to be low (i.e., high flows), (c) marking Chinook salmon so that fish from a particular trial are distinguishable from other trials, and (d) testing the effect of trial frequency on weekly passage estimates.*

> ***Recommendation:*** *Investigate the differences in capture efficiency of hatchery and naturally produced Chinook salmon at various life-stages. The ability to use*

hatchery fish at times when insufficient naturally produced fish are available would reduce the need to use the average season efficiency.

Juvenile salmonid passage.—Based on non-overlapping 95% confidence intervals, passage of juvenile spring Chinook salmon at the LBC trap was higher for BY03 than for BY01 and BY02, passage of juvenile fall Chinook salmon was higher than BY02 but lower than all other years, and passage of BY04 juvenile late-fall Chinook salmon and the combined 03-04 age 1+ and yoy rainbow trout/steelhead passage was lower at the LBC trap than in all other years (Table 12). A variety of factors may be responsible for the increased or reduced juvenile passage indices, including adult passage, adult survival and spawning success, survival to emergence, high flows, and inaccurate estimates of actual juvenile passage.

The annual JPI for BY03 spring Chinook salmon at the LBC trap was much higher than in either 2001 or 2002. Reasons for the increase may be related to annual variation in spawn timing and its affect on the amount of overlap of actual fall run into the spring-run length-at-date category. Adult fall Chinook salmon are thought to begin migrating into Battle Creek in August (Brown and Alston 2007). The number of adult Chinook observed passing the CNFH barrier weir in August was much higher in 2003 (N=106) than in 2001 (N=13) or 2002 (N=42) (Brown and Newton 2002; Brown et al. 2005; Brown and Alston 2007). An increase in the number of early arriving fall Chinook salmon may produce a greater number of early emerging juveniles which could be misclassified as spring Chinook salmon. Determining the amount and variability of size overlap is necessary for improving the reliability of our passage estimates. Genetic analyses of tissue samples collected during these periods of overlap could be useful for determining the amount of overlap that occurs as long as the available methods are capable of accurately differentiating runs of Chinook salmon. No estimates of adult spring Chinook salmon escapement were made below the barrier weir; and although it is possible that some spawned downstream there would be no way to distinguish juveniles produced above the barrier weir from those produced below the barrier weir. Ideally all adult spring Chinook salmon were passed upstream of the barrier weir, and passage of juvenile spring-run is likely better estimated using the UBC trap.

The increase in BY03 fall Chinook salmon annual JPI at the LBC trap, relative to BY02, may be directly related to adult escapement and spawning success below the barrier weir, and moderate flows and temperatures. In 2003, the estimated adult escapement of fall Chinook salmon below the weir was 153,027 of which 88,263 were taken into Coleman National Fish Hatchery (CNFH; CDFG 2007)). The remaining 64,764 estimated to be downstream of the barrier weir, was the fourth highest escapement on record, but about a third of the record 2002 escapement of 397,149 (CDFG 2007). In 2002, low flows and high water temperatures could have contributed to the high levels of pre-spawn mortality (87.5%; C. Harvey-Arrison, CDFG, personal communication) and also reduced spawning success in the fall (Whitton et al. 2007b). Redd superimposition likely also occurred, further impacting juvenile production. Conversely, the much lower escapement observed in 2003 appears to have led to increased fall Chinook salmon spawning success as evidenced from the five-fold increase in the annual JPI.

Higher mean daily flows and more moderate mean daily temperatures during the current report period may have improved adult Chinook salmon spawning success and increased survival to emergence, resulting in increased juvenile passage. Several high flow events occurred in December, but only two had maximum flows >3,000 cfs; therefore scouring of fall and spring Chinook salmon redds was likely limited or did not occur. Although mean daily temperatures were high in late September and early October, they had dropped considerably by late October (Figure 18). The range for maximum embryo survival is 5 to 13 ºC (Moyle 2002). No redd surveys were conducted below the barrier weir after September 19, 2003, and as of that date no redds had been observed. Although redds were first observed above the barrier weir in mid-September, it appears that spawning in the lower watershed did not occur until after September 19; therefore, water temperatures may have been within the range for maximum embryo survival or exposure to higher than ideal temperatures was limited to a short period of time.

The release of hatchery fall Chinook salmon in April likely influenced the accuracy of our fall Chinook salmon weekly JPI's during that time. No hatchery fall Chinook salmon were marked in 2004; therefore we were not able to estimate the proportion of hatchery fish captured in the LBC trap. To prevent overestimating daily catch of larger fish, we did not include most fish > 45mm in our daily counts from April 19 to mid-June which resulted in an underestimation of our daily catch during this period. Most of the larger Chinook salmon captured during this time are spring and fall-run. Excluding these fish likely also affected our life-stage composition for these runs. Underestimating catch of fall run during this period may partially explain why the BY03 JPI was statistically lower than brood years 1998 through 2001. In addition, only marked fall Chinook salmon released by the hatchery were removed from daily catch for BY98, BY99 and BY00; therefore, annual passage estimates for these years may have been overestimated and could also explain why the annual passage estimates for those years were significantly higher than the annual passage estimate for BY03.

The annual JPI estimate for BY04 late-fall Chinook salmon in LBC was lower than all previous brood years, but reasons for the decrease are not readily apparent because of confounding factors. As seen with spring Chinook salmon, the length-at-date criteria used to assign run designation does not appear to be accurate because there was overlap with fall Chinook salmon. In other words, small Chinook salmon fry that were classified as fall-run in April through May could have been late fall Chinook salmon. Annual variation in spawn timing may account for the decrease if early arriving late-fall Chinook salmon spawned earlier than in previous years and as a result, were misclassified as fall Chinook salmon. In addition, in-river adult escapement estimates were not available for late-fall Chinook salmon; therefore, it is unknown if a decrease in adult escapement occurred. The only estimate of escapement available was the number taken into the hatchery. In 2004, 5,098 late-fall Chinook salmon were taken into the hatchery which is the second highest number on record (7,075 in 1999; CDFG 2007), but hatchery staff only passed 40 unclipped (naturally produced) Chinook salmon above the barrier weir prior to March 2, 2004, which is lower than the previous 3 years. In mid to late February, there were two high flow events with peak flows >141.6 m^3/s (5,000 cfs) that may have scoured redds prior to emergence; however, the minimum flows necessary to cause redd scouring have not been determined.

Rainbow trout/steelhead annual JPI estimates at the lower trap were significantly lower in 2003-2004 than all previous estimates. No estimates of adult rainbow trout/steelhead escapement or spawning success were made below the barrier weir; and although it is possible that some spawned downstream there would be no way to distinguish juveniles trout produced above the barrier weir from those produced below the barrier weir. There were two high flow events in mid to late February with peak flows >141.6 m^3/s (5,000 cfs) that may have cause redd souring prior to emergence, or washed juvenile trout downstream without being captured since the traps were not operated during these flow events. The UBC trap is likely better used to estimate passage of rainbow trout/steelhead in Battle Creek because of the limited information available for rainbow trout/steelhead populations below the barrier weir.

The spring Chinook salmon annual JPI for BY03 at the UBC trap was significantly higher than all previous brood years, and the BY03 fall Chinook salmon annual JPI was significantly lower than BY98 and BY99 but significantly higher than BY01 and BY02 (Table

12). The increase of both spring and fall run JPI in BY03 relative to BY01 and BY02 was likely a result of increased adult passage and improved flows and water temperatures. Interim flows (i.e., minimum instream flows) of at least 0.85 m^3/s (30 cfs) were provided in both the north and south forks of Battle Creek in 2003 as well as 1998 through 2000. But, in 2001 and 2002, interim flows were greatly reduced in South Fork Battle Creek for most or all of the holding and spawning period of spring and fall Chinook; down to about 0.14 m^3/s (5 cfs) in 2001 and 0.28 m^3/s (10 cfs) in 2002 (Whitton et al. 2007b). This led to high water temperatures and reduced habitat. Additionally, an above average proportion of Chinook salmon held and spawned in the south fork in 2001 and 2002 (Newton et al. 2007) and were subjected to these less suitable environmental conditions. Estimated adult Chinook passage at the barrier weir from March through August was higher in 2003 than 2001 and 2002; 234 compared to 116 and 222 respectively. Furthermore, passage in 2003 may have been underestimated. In 2003, mean daily flows from April 24 to June 17 were the highest since spring 1998. This period of increased flows coincided with what was likely the peak passage for adult spring Chinook salmon; therefore, additional salmon likely jumped upstream of the barrier weir in 2003, which was supported by the total number of redds observed during fall snorkel surveys (n=176; Alston and Brown (2007). Alston and Brown (2007) estimated a spawning population of 353 spring and fall Chinook salmon based on redd counts. In contrast, only 78 redds were observed during snorkel surveys in 2002 (Brown et al. 2005).

The BY03 fall Chinook JPI at the UBC trap was lower but the spring run JPI was higher relative to BY98 and BY99. This increase in BY03 spring run JPI may be the result of the degree and timing in overlap between spring and fall-run in relation to the length-at-date criteria. The combined JPI's for spring and fall Chinook salmon at the UBC trap were lower for BY03 than for BY98 and BY99 but, taken separately, the spring-run JPI was higher. Water year 1998 was the wettest on record (since 1962) and many adult spring and fall Chinook likely jumped over the barrier weir undetected. According to the fixed length-at-date criteria, the proportion of juvenile spring to fall Chinook salmon passage was much higher in 2003. In 2003, 7.4% of the combined spring and fall Chinook salmon juvenile passage was spring-run, while in 1998 and 1999 spring-run were 0.4 and 2.5%, respectively. Although it appears that either passage or spawning success of adult spring Chinook salmon has increased in proportion to fall Chinook salmon, it is possible that there is just less overlap of fall run into the spring run category when using the length-at-date criteria to assign a run-designation to juvenile salmon. Less overlap in fork length may occur if spring Chinook salmon spawn earlier or higher water temperatures result in earlier emergence timing for fry. However, Alston and Brown (2007) found that during the holding periods all Chinook salmon were subjected to water temperatures which could result in some mortality and reduced fertility. They also stated that spring Chinook salmon delayed spawning until temperatures were more suitable, but felt that redds were exposed to good temperatures for most of the incubation period. Genetic analyses of tissue samples collected during these periods of overlap could be useful for determining the amount of overlap that occurs as long as the available methods are capable of accurately differentiating runs of Chinook salmon. Alternatively, it may be useful to combine annual spring and fall run JPI's for interannual comparisons or when investigating possible correlations with adult escapement estimates and environmental conditions during the holding and spawning periods.

Differences in life-stage composition were also observed between BY03 and BY98 and BY99 spring Chinook salmon (Whitton et al. 2006). However, BY98 is not directly comparable because life-stages were not assigned until March 1999. Life-stage composition for BY99 was 7% fry, 10.8% parr, 76.3% silvery parr, and 5.9% smolt, while in 2003; the fry were 26.5%, parr 6.5%, silvery parr 26.3%, and smolt 40.0%. It appears there was a large increase in the proportion of fry and smolt and a decrease in the proportion of silvery parr captured in the UBC trap. The differences in life-stage composition may be the result of the overlap in size between fall and spring Chinook salmon that occurs when using the length-at-date criteria to determine the run designation. In addition, life-stage was assigned based on physical characteristics, so it is possible that some of the differences in composition are because life-stage assignment can be subjective.

The BY04 late-fall Chinook salmon annual JPI of 1,145 at the UBC trap was significantly lower than the BY02 (7,628) and BY03 (6,673) JPI's. Reduced adult passage, high flows, and inaccurate run designation may account for the apparent decrease in juvenile late-fall Chinook salmon passage. From October 2003 through February 2004 hatchery staff passed 40 adult late-fall Chinook salmon upstream of the barrier weir, which is lower than in the previous 3 years (57 to 216). It is possible that some of these fish were not late-fall, but run-timing suggests otherwise. Based on run-timing, coded-wire tag recoveries, and genetic analyses an additional 2 late-fall Chinook salmon were passed though the barrier weir fish ladder after March 1, 2004, which is also lower than in previous years (Alston and Brown 2007). Three storm events in mid to late-February had maximum flows between 146.4 and 150.6 m^3/s (5,170 to 5,320 cfs). It is possible that some redds in either the forks or mainstem were scoured during these events. The fork-length overlap that occurs between fall and late-fall Chinook salmon fry may also account for some of the decrease because small Chinook salmon fry classified as fall-run in April and May 2004 were more likely late-fall Chinook salmon.

The combined 2004 rainbow trout/steelhead annual JPI estimate of 3,596 for at the UBC trap was significantly lower than all previous estimates (Table 13). A reduction in adult passage and high flows may have contributed to the decrease. Between October 2003 and August 29, 2004 there were 633 clipped and unclipped rainbow trout/steelhead passed upstream of the barrier weir, while in 2001 to 2003, the number of clipped and unclipped passed upstream of the weir varied from 1, 318 in 2003 to 1,838 in 2002 (Newton et al. 2007). The 2003 adult passage is less than half of any previous passage, which may explain the significant decrease observed in juvenile passage.

In Battle Creek rainbow trout/steelhead fry typically begin migrating past the UBC trap in February and March, but in 2004 few fry were captured in the traps in comparison to 2000 and 2002 (Whitton et al. 2006; Whitton et al. 2007a). Between February 1 and March 15, 2004 there were 5 d when stream flows at the USGS gauge station, located downstream of the UBC trap, exceeded 85.0 m^3/s (3,000 cfs). Three storms events in mid to late-February had maximum flows in the mainstem between 146.4 and 150.6 m^3/s (5,170 to 5,320 cfs). It is possible that either redds were scoured during these events or that juvenile trout were flushed downstream without being captured in the UBC trap. During the 2001-2002 report period, yolk-sac fry and fry accounted for 54% of all trout captured in the UBC trap, while during the current report period the same life-stages were only 8.6% of all trout captured in the trap. In addition, yolk-sac fry in the LBC trap were 12.9% of trout captured in the trap, while during the 2001-2002 and 2002-2003 report periods the yolk-sac fry life stage was less than 1% of all trout captured. The increased proportion of yolk-sac fry in 2004 may be an indication of redd scouring.

Recommendation: *Investigate the relationship between flows and redd scour and the impact on juvenile passage.*

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References

Bailey, N. T. J. 1951. On estimating the size of mobile populations from capture-recapture data. Biometrika 38:293-306.

Brown, M. R., and J. M. Newton. 2002. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California from March through October 2001. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Brown, M. R., and N. O. Alston. 2007. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from November 2002 through November 2003. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Brown, M. R., N. O. Alston, and J. M. Newton. 2005. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March through November 2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Buckland, S. T., and P. H. Garwaite. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. Biometrics 47: 255-268.

CDFG (California Department of Fish and Game). 2007. GrandTab (Updated: February 4, 2007). Native Anadromous Fish and Watershed Branch. Available: www.delta.dfg.ca.gov/AFRP/documents/GrandTab020407.xls. (June 2007).

CVPIA (Central Valley Project Improvement Act). 1997. CVPIA comprehensive assessment and monitoring program: standard protocol for rotary screw trapping. Central Valley Fish and Wildlife Restoration Program Office, Sacramento, CA.

Carlson, S. R., L. G. Coggins Jr., and C. O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5(2):88-102.

Chapman, D. W., and T. C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 *in* T. G. Northcote, editor. Symposium on

Salmon and Trout in Streams. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC. 388p.

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1:54-77.

Everest, F. H. and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29:91-100.

Greene, S. 1992. Estimated winter-run Chinook salmon salvage at the state water project and Central Valley Project delta pumping facilities. Memorandum dated 8 May 1992, from Sheila Greene, State of California Department of Water Resources to Randall Brown, California Department of Water Resources. 3 pp., plus 15 pp. tables.

Griffith, J., R. Roger, and J. Drotts. 2001. 2001 Stillaguamish River smolt trapping project. Stillaguamish Tribe of Indians, Arlington, WA.

Healey, M. C. 1991. Life history of Chinook salmon. Pages 311 - 393 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, University of British Columbia, Vancouver, B.C, Canada.

Jones & Stokes. 2004. Battle Creek Salmon and Steelhead Restoration Project action specific implementation plan. Draft. April. (J&S 03-035.) Sacramento, CA.

Martin, C. D., P. D. Gaines and R. R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U. S. Fish and Wildlife Service, Red Bluff, CA.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley, California.

Newton, J. M., N. O. Alston, and M. R. Brown. 2007. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March 2006 through November 2006. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Roper, B. and D. Scarnecchia. 1996. A comparison of trap efficiencies for wild and hatchery age-0 Chinook salmon. North American Journal of Fisheries Management 16:214-217.

Roper, B. and D. Scarnecchia. 1999. Emigration of age-0 Chinook salmon (Oncorhychus tshawytscha) smolts from the upper South Umpqua River basin, Oregon, USA. Canadian Journal of Fisheries and Aquatic Sciences 56: 939-946.

Steinhorst, K., Y. Wu, B. Dennis, and P. Kline. 2004. Confidence intervals for fish outmigration estimates using stratified trap efficiency methods. Journal of Agricultural, Biological, and Environmental Statistics 9: 284-299.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz, and K V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837-851.

USFWS (U.S. Fish and Wildlife Service). 1997. Revised Draft Restoration Plan for the Anadromous Fish and Restoration Program. A plan to increase natural production of anadromous fish in the Central Valley of California. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish and Restoration Program Core Group. May 30, 1997.

USFWS (U.S. Fish and Wildlife Service). 2001. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of Chinook salmon and steelhead trout. Red Bluff, CA.

USFWS (U.S. Fish and Wildlife Service) and USBR (U.S. Bureau of Reclamation). 2002. Comprehensive Assessment and Monitoring Program (CAMP) Annual Report 2000. Prepared by CH2M HILL, Sacramento, California.

Volkhardt, P.T., L. Fleischer, T. Miller, and S. Schonning. 2005. 2004 juvenile salmonid production evaluation report: Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife –Fish Program FPA05-13.

Ward, M. B., and W. M. Kier. 1999. Battle Creek salmon and steelhead restoration plan. Report by Kier Associates to Battle Creek Working Group.

Whitton, K. S., J. M. Newton, D. J. Colby, and M. R. Brown. 2006. Juvenile salmonid monitoring in Battle Creek, California, from September 1998 to February 2001. USFWS Data Summary Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, CA.

Whitton, K. S., J. M. Newton, and M. R. Brown. 2007a. Juvenile salmonid monitoring in Battle Creek, California, from July 2001 through September 2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, CA.

Whitton, K. S., J. M. Newton, and M. R. Brown. 2007b. Juvenile salmonid monitoring in Battle Creek, California, from October 2002 through September 2003. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, CA.

Tables

Table 1. Life-stage summary of spring, fall, late-fall, and winter Chinook salmon and rainbow trout/steelhead captured at the Lower and Upper Battle Creek rotary screw traps from October 1, 2003 through September 30, 2004.

	Spring Chinook		Fall Chinook		Late-Fall Chinook		Winter Chinook		Rainbow	
Life Stage	#	%	#	%	#	%	#	%	#	%
					Lower Battle Creek (LBC)					
Fry	14	7.4	12,489	76.1	1,019	77.9	1	0.6	16	22.9
Parr	8	4.2	1,156	7.1	91	7.0	36	22.6	28	40.0
Silvery Parr	100	52.9	344	2.1	44	3.4	103	64.8	12	17.1
Smolt	67	35.5	56	0.3	12	0.9	19	12.0	5	7.1
Totals	*189*	*100*	*16,407*	*100*	*1,308*	*100*	*159*	*100*	*70*	*100*
					Upper Battle Creek (UBC)					
Yolk Sac Fry	3	0.7	181	2.3	0	0	---	---	2	0.8
Fry	110	26.5	7,041	91.4	35	85.4	---	---	19	7.8
Parr	27	6.5	164	2.1	1	2.4	---	---	188	77.1
Silvery Parr	109	26.3	216	2.8	0	0	---	---	31	12.7
Smolt	166	40.0	104	1.4	5	12.2	1	100	4	1.6
Totals	*415*	*100*	*7,706*	*100*	*41*	*100*	*1*	*100*	*244*	*100*

[a] Two additional late-fall Chinook salmon (silvery parr) were sampled at the LBC trap from 12/02//04 to 12/31/04.

Table 2. Summary of the mark-recapture trials conducted at the Lower Battle Creek rotary screw trap (LBC) from October 1, 2003 through September 30, 2004. Marked fish for all LBC trials were released at the Jelly's Ferry Bridge. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. Trials conducted during the same week were pooled to calculate the average weekly trap efficiency. During weeks when recaptures were <7 mark-recapture data from adjacent weeks were pooled if flows and trap efficiencies were similar, otherwise the season average trap efficiency (*E=0.063*) was used to calculate weekly passage. The season average trap efficiency was also used to calculate passage during weeks when no mark-recapture trials were conducted. Trials highlighted with **bold text** were not used.

Release Date	Time of Release	Number Released	Recaptures	Efficiency[a]	Pooled /Season Avg. Efficiency	Weekly Mean Flow, m^3/s (cfs)
01/14/04	15:27	165	20	0.127	---	12.0 (425)
01/27/04	23:10	514	35	0.070	0.049	19.1 (676)
01/30/04 [b]	17:21	377	4	0.013	0.049	19.1 (676)
02/06/04	17:16	396	25	0.065	---	18.6 (657)
02/10/04	18:58	401	36	0.092	0.096	16.5 (583)
02/13/04	17:47	400	40	0.102	0.096	16.5 (583)
02/24/04[c]	**14:14**	**244**	**5**	**0.024**	*0.063*	39.2 (1,348)
03/05/04	18:37	299	12	0.043	---	22.0 (776)
03/09/04	17:15	404	18	0.047	0.044	20.1 (709)
03/12/04	18:21	353	14	0.042	0.044	20.1 (709)
03/12/04	**18:21**	**5**	**0**	**---**	*0.063*	20.1 (709)
03/16/04	18:24	379	22	0.061	---	21.2 (747)
03/26/04	17:53	252	10	0.043	---	20.5 (725)

[a] Bailey's Efficiency was calculated by: $\hat{E} = \frac{r+1}{m+1}$, where r = recaptures and m = number of marked fish released.

[b] This trial was conducted at ½-cone status, but since there were < 7 recaptures, it was not considered valid; therefore, to pool the results with the full-cone trial conducted earlier in the week, the recaptures were doubled to make the trials equivalent. Catch was also doubled on the days the trap was operated at ½-cone.

[c] This trial was not valid as the trap only operated 1d before being pulled because of high flows. Prior to estimating passage, catch was doubled on all days the trap was operated at ½-cone.

Table 3. Summary of the mark-recapture trials conducted at the Upper Battle Creek rotary screw trap (UBC) during October 1, 2003 through September 30, 2004. Marked fish for all UBC trials were released at Intake 3. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. Trials conducted during the same week were pooled to calculate the average weekly trap efficiency. During weeks when recaptures were <7, mark-recapture data from adjacent weeks were pooled if flows and trap efficiencies were similar, otherwise the season average trap efficiency (*E=0.078*) was used to calculate weekly passage. The season average trap efficiency was also used to calculate passage during weeks when no mark-recapture trials were conducted. Trials highlighted with **bold text** were not used.

Release Date	Release Time	Number Released	Recaptures	Efficiency[a]	Pooled /Season Avg. Efficiency	Weekly Mean Flow, m^3/s (cfs)
01/14/04	15:46	147	15	0.108	---	12.0 (425)
01/27/04	23:23	428	35	0.084	0.109	19.1 (676)
01/30/04	17:02	387	53	0.139	0.109	19.1 (676)
02/06/04	17:00	390	21	0.056	---	18.6 (657)
02/10/04	19:12	399	41	0.105	0.109	16.5 (583)
02/13/04	18:05	400	45	0.115	0.109	16.5 (583)
02/24/04	14:28	282	19	0.071	---	38.2 (1,348)
03/05/04	18:49	300	27	0.093	---	22.0 (776)
03/09/04	17:13	425	27	0.066	0.083	20.1 (709)
03/12/04	17:40	450	45	0.102	0.083	20.1 (709)
03/26/04	18:05	269	26	0.100	---	20.5 (725)
03/26/04[c]	**18:05**	**26**	**1**	**0.074**	*0.078*	20.5 (725)
04/02/04	18:10	179	4	0.028	0.021	17.6 (622)
04/02/04[d]	1810	93	2	0.032	0.021	17.6 (622)
04/09/04	15:35	157	2	0.019	0.021	16.8 (593)
04/16/04	14:06	597	12	0.022	---	15.7 (556)

[a] Bailey's Efficiency is calculated by: $\hat{E} = \frac{r+1}{m+1}$, where r = recaptures and m = marks.

[b] Due to high flows, the UBC trap was pulled on 01/22/03 after the release.

[c] This mark-recapture trial done with larger Chinook salmon was not used because two few were marked or recaptured.

[d] This trial using larger fish was pooled with a trial conducted the same day with smaller fish because trap efficiency was similar for both trials.

Table 4. Weekly summary of brood year 2003 juvenile spring Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which spring Chinook salmon were captured are included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
12/02/03	0.063[a]	2	32	6	24	41	23	45
12/09/03	0.063[a]	2	32	6	24	41	23	45
02/10/04	0.096	693	7,218	797	5,976	8,551	5,850	8,964
02/17/04	0.063[a]	234	3,725	633	2,819	4,817	2,688	5,254
02/25/04	0.063[a]	53	844	153	639	1,138	609	1,190
03/02/04	0.043	4	92	29	60	150	57	171
03/16/04	0.061	4	66	14	48	89	45	101
03/23/04	0.043	11	253	119	155	398	146	464
03/30/04	0.063[a]	56	891	161	675	1,203	343	1,257
04/06/04	0.063[a]	31	494	87	374	638	356	696
04/13/04	0.063[a]	73	1,162	209	880	1,568	839	1,639
Totals	**---**	***1,163***	***14,809***	***1,076***	***13,139***	***16,632***	***12,809***	***16,922***

[a] Season average efficiency, which was based on valid trials conducted January 14, 2004 through March 26, 2004, was used to estimate passage during weeks when mark-recapture trials were not conducted.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 5. Weekly summary of brood year 2003 juvenile fall Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
11/25/03	0.063[a]	3	48	9	36	64	34	71
12/02/03	0.063[a]	29	462	84	349	597	333	651
12/09/03	0.063[a]	209	3,327	581	2,518	4,302	2,458	4,693
12/16/03	0.063[a]	370	5,890	1,089	4,458	7,947	4,251	8,308
12/23/03	0.063[a]	812	12,927	2,313	9,784	16,714	9,329	18,233
12/30/03	0.063[a]	1,006	16,015	2,831	12,121	20,707	11,557	22,589
01/06/04	0.063[a]	2,241	35,676	6,123	27,001	46,127	26,358	48,133
01/13/04	0.127	8,226	65,025	13,366	47,087	85,345	44,049	97,537
01/20/04	0.063[a]	18,160	289,098	52,131	218,806	373,793	213,596	427,192
01/27/04	0.049	31,932	647,349	100,094	508,631	837,745	491,092	890,105
02/03/04	0.065	32,933	502,862	109,246	373,554	688,126	353,362	769,082
02/10/04	0.096	56,916	592,813	64,974	496,159	713,229	480,491	736,236
02/17/04	0.063[a]	25,322	403,114	73,906	305,220	544.087	291,023	568,819
02/24/04	0.063[a]	6,629	105,530	18,632	79,871	142,379	76,156	148,851
03/02/04	0.043	6,391	147,485	44,686	95,865	213,033	91,300	239,663
03/09/04	0.044	9,610	220,739	38,594	169,404	291,375	158,356	303,516
03/16/04	0.061	3,450	57,000	11,614	40,969	77,118	38,558	81,938
03/23/04	0.043	894	20,562	6,437	13,305	32,312	11,904	37,697
03/30/04	0.063[a]	175	2,786	504	2,109	3,759	2,010	3,930
04/06/04	0.063[a]	198	3,152	599	2,386	4,253	2,275	4,658
04/13/04	0.063[a]	564	8,979	1,644	6,634	12,114	6,332	12,664
04/20/04	0.063[a]	74	1,178	223	892	1,589	850	1,662
04/27/04	0.063[a]	36	573	100	414	741	404	773
05/04/04	0.063[a]	15	239	45	181	322	172	353
05/11/04	0.063[a]	14	223	42	169	301	161	314
05/18/04	0.063[a]	10	159	29	120	215	115	225

Table 5. (Cont.)

06/15/04	0.063[a]	20	318	58	241	430	230	449
06/22/04	0.063[a]	20	318	58	241	430	230	449
06/29/04	0.063[a]	1	16	3	12	21	11	22
07/06/04	0.063[a]	2	32	6	24	43	23	47
07/20/04	0.063[a]	4	64	11	48	86	46	90
Totals	---	***206,266***	***3,143,959***	***196,092***	***2,863,640***	***3,492,043***	***2,821,952***	***3,598,515***

[a] Season average efficiency based on valid trials conducted January 14, 2004 through March 26, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 6. Weekly summary of brood year 2004 juvenile late-fall Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which late-fall Chinook salmon were captured are included. However, several weeks outside of the reporting dates (December 2 to 24, 2004) are included to allow estimation of the total annual JPI for brood year 2004 (below dashed line).

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
03/30/04	0.063[a]	2	32	5	24	41	23	45
04/06/04	0.063[a]	30	478	83	361	618	345	674
04/13/04	0.063[a]	69	1,098	187	831	1,420	793	1,549
04/20/04	0.063[a]	134	2,133	402	1,615	2,878	1,539	3,009
04/27/04	0.063[a]	60	955	174	723	1,235	689	1,347
05/04/04	0.063[a]	101	1,608	275	1,217	2,079	1,160	2,268
05/11/04	0.063[a]	314	4,999	930	3,783	6,463	3,607	7,051
05/18/04	0.063[a]	467	7,434	1,293	5,627	10,030	5,493	10,486
05/25/04	0.063[a]	194	3,088	551	2,337	3,993	2,282	4,356
06/01/04	0.063[a]	34	541	92	410	700	391	763
06/08/04	0.063[a]	29	462	86	349	623	333	651
06/15/04	0.063[a]	11	175	31	133	236	126	247
06/22/04	0.063[a]	4	64	12	48	86	46	90
06/29/04	0.063[a]	3	48	8	35	62	34	67
07/06/04	0.063[a]	2	32	6	24	43	23	47
07/13/04	0.063[a]	1	16	3	12	21	11	22
				11				
12/02/04 to 12/31/04		2	30	6	22	41	21	45
Totals	***---***	***1,457***	***23,193***	***1,800***	***20,497***	***26,193***	***20,103***	***26,875***

[a] Season average efficiency, which was based on valid trials conducted January 14, 2003 through March 26, 2004, was used to estimate passage during weeks when mark-recapture trials were not conducted.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.
[d] The 2004 to 2005 season average trap efficiency was used to estimate passage for weeks outside of the reporting period.

Table 7. Weekly summary of rainbow trout/steelhead passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Weekly estimates listed above the dotted line are for trout from previous brood years (age 1+). Weekly estimates below the line are for brood year 2004 trout captured during the reporting period. Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Weeks with no catch are not included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
Previous Brood Years (Age 1+)								
10/21/03	0.063[a]	4	64	11	48	86	46	90
10/28/03	0.063[a]	1	16	3	12	21	11	22
11/04/03	0.063[a]	2	32	6	24	41	23	45
11/11/03	0.063[a]	1	16	3	12	21	11	22
11/18/03	0.063[a]	2	32	6	24	41	23	45
12/23/03	0.063[a]	1	16	3	12	21	11	22
01/13/04	0.127	1	8	1.6	5.7	10.4	5.3	11.1
02/03/04	0.065	2	31	6	22	42	21	47
02/10/04	0.096	1	10	1.1	8.7	12.3	8.5	12.9
02/17/04	0.063[a]	8	127	22	96	172	94	180
02/24/04	0.063[a]	3	48	9	37	64	35	67
03/09/04	0.044	1	23	4	17	30	16	32
05/04/04	0.063[a]	2	32	6	24	43	22	45
05/18/04	0.063[a]	1	16	3	12	21	11	22
Totals	---	***30***	***471***	***32***	***421***	***526***	***413***	***538***
Brood Year 2004 (YOY)								
02/24/04	0.063[a]	2	32	6	24	43	22	45
03/02/04	0.043	2	46	14	30	75	29	86
03/09/04	0.044	8	184	33	138	243	132	253
03/16/04	0.061	3	50	10	36	67	35	76
03/23/04	0.043	7	161	51	104	253	93	295
03/30/04	0.063[a]	1	16	3	12	21	11	24
04/06/04	0.063[a]	2	32	6	25	43	24	45
04/13/04	0.063[a]	5	80	15	59	104	57	112

Table 7 (Cont.)

04/20/04	0.063[a]	10	159	28	120	206	112	225
04/27/04	0.063[a]	2	32	6	24	41	23	45
05/04/04	0.063[a]	6	96	17	72	129	69	135
05/11/04	0.063[a]	3	48	8	36	64	34	67
05/18/04	0.063[a]	3	48	9	36	64	34	67
05/25/04	0.063[a]	2	32	6	24	43	23	45
06/01/04	0.063[a]	1	16	3	12	21	11	22
06/08/04	0.063[a]	3	48	9	36	64	34	67
06/15/04	0.063[a]	1	16	3	12	21	11	22
06/22/04	0.063[a]	2	32	6	24	43	23	47
07/20/04	0.063[a]	1	16	3	12	21	11	22
Totals	**---**	***64***	***1,144***	***73***	***1,031***	***1,268***	***1,013***	***1,301***

[a] Season average efficiency based on valid trials conducted January 14, 2004 through March 26, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 8. Weekly summary of brood year 2003 juvenile spring Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which spring Chinook salmon were captured are included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
11/25/03	0.078[a]	8	102	16	79	131	77	140
12/02/03	0.078[a]	42	537	84	421	687	404	737
12/09/03	0.078[a]	90	1,151	187	884	1,473	850	1,578
12/16/03	0.078[a]	3	38	6	31	51	29	53
01/27/04	0.109	1	9	0.9	7.8	10.8	7.6	11.2
02/03/04	0.056	17	302	63	222	415	208	475
02/10/04	0.109	7	64	6	54	75	53	77
02/17/04	0.078[a]	2	26	4	20	34	19	35
02/24/04	0.071	8	113	25	81	151	75	174
03/02/04	0.093	8	86	17	65	115	62	127
03/09/04	0.083	3	36	4	30	44	29	45
03/16/04	0.078[a]	8	102	16	80	131	77	140
03/23/04	0.100	20	200	36	150	270	142	284
03/30/04	0.021	39	1,863	710	1,118	2,795	1,048	3,354
04/06/04	0.021	51	2,437	822	1,462	3,655	1,371	4,386
04/13/04	0.022	69	3,174	977	2,063	4,585	1,965	5,158
04/20/04	0.078[a]	50	640	103	501	818	481	877
04/27/04	0.078[a]	19	243	39	190	311	179	333
05/04/04	0.078[a]	9	115	19	88	147	85	158
05/11/04	0.078[a]	2	26	4	20	33	19	35
Totals	---	***456***	***11,264***	***1,512***	***9,251***	***14,026***	***8,973***	***14,709***

[a] Season average efficiency based on valid trials conducted January 14 through April 16, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 9. Weekly summary of brood year 2003 juvenile fall Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
11/25/03	0.078[a]	2	26	4	20	33	19	35
12/02/03	0.078[a]	30	384	59	301	491	289	526
12/09/03	0.078[a]	424	5,425	860	4,164	6,939	4,082	7,435
12/16/03	0.078[a]	779	9,967	1,600	7,806	13,189	7,500	13,660
12/23/03	0.078[a]	796	10,184	1,663	7,817	13,477	7,516	13,958
12/30/03	0.078[a]	360	4,606	715	3,535	5,892	3,399	6,095
01/06/04	0.078[a]	2,100	26,868	4,378	21,043	35,555	20,218	36,825
01/13/04	0.108	1,004	9,287	2,322	6,461	13,508	5,944	14,859
01/20/04	0.078[a]	927	11,860	2,615	9,103	15,695	8,753	16,256
01/27/04	0.109	2,420	22,188	2,318	18,806	26,329	18,117	27,051
02/03/04	0.056	1,410	25,060	5,581	17,784	34,457	17,228	36,754
02/10/04	0.109	320	2,943	298	2,485	3,459	2,415	3,657
02/17/04	0.078[a]	132	1,689	275	1,296	2,160	1,246	2,315
02/24/04	0.071	61	863	192	617	1,233	595	1,328
03/02/04	0.093	66	710	137	537	946	509	1,046
03/09/04	0.083	10	120	14	101	146	96	151
03/16/04	0.078[a]	15	192	33	147	254	142	263
03/23/04	0.100	26	260	51	195	351	185	390
03/30/04	0.021	45	2,150	663	1,290	3,225	1,209	3,870
04/06/04	0.021	40	1,911	697	1,147	2,867	1,012	3,440
04/13/04	0.022	51	2,346	676	1,525	3,389	1,452	3,812
04/20/04	0.078[a]	42	537	84	421	687	404	737
04/27/04	0.078[a]	27	345	56	271	457	255	473
05/04/04	0.078[a]	33	422	67	324	540	318	579
05/11/04	0.078[a]	36	461	76	354	589	340	631
05/18/04	0.078[a]	25	320	53	246	423	236	438
05/25/04	0.078[a]	16	205	33	160	271	154	281
06/01/04	0.078[a]	2	26	4	20	33	19	35
06/08/04	0.078[a]	3	38	6	29	49	28	53
Totals	---	***11,202***	***141,393***	***8,503***	***128,557***	***155,900***	***127,193***	***160,251***

[a] Season average efficiency based on valid trials conducted January 14 through April 16, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 10. Weekly summary of brood year 2004 juvenile late-fall Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). No additional late-fall Chinook salmon were captured after September 30, 2004.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
04/13/04	0.022	21	966	293	628	1,570	598	1,794
04/20/04	0.078[a]	9	115	18	90	147	87	158
04/27/04	0.078[a]	5	64	10	50	82	48	85
Totals	---	***35***	***1,145***	***294***	***809***	***1,732***	***768***	***1,968***

[a] Season average efficiency based on valid trials conducted January 14 through April 16, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 11. Weekly summary of rainbow trout/steelhead passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Weekly estimates listed above the dotted line are for trout from previous brood years (age 1+). Weekly estimates below the line are for brood year 2004 trout captured during the reporting period. Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Weeks with no catch are not included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
Previous Brood Years (Age 1+)								
11/04/03	0.078[a]	2	26	4	20	33	19	35
11/25/03	0.078[a]	1	13	2	10	16	9	18
12/09/03	0.078[a]	2	26	4	20	33	19	34
12/16/03	0.078[a]	1	13	2	10	16	9	18
12/23/03	0.078[a]	7	90	14	70	115	67	123
12/30/03	0.078[a]	5	64	10	50	79	47	85
01/06/04	0.078[a]	2	26	4	20	33	19	35
01/27/04	0.109	1	9	0.9	7.8	10.8	7.6	11.2
02/02/04	0.056	2	36	8	25	49	24	56
02/10/04	0.109	3	28	3	24	33	23	34
02/17/04	0.078[a]	15	192	29	150	246	144	254
02/24/04	0.071	8	113	25	81	151	75	174
03/01/04	0.093	5	54	10	40	72	39	75
03/09/04	0.083	3	36	4	30	44	29	45
03/16/04	0.078[a]	5	64	10	50	82	47	88
03/23/04	0.100	1	10	1.9	7.5	13.5	7.1	14.2
05/04/04	0.078[a]	1	13	2	10	16	9	18
05/11/04	0.078[a]	1	13	2	10	16	9	18
Totals	***---***	***65***	***826***	***45***	***753***	***903***	***741***	***917***
Brood Year 2004 (YOY)								
03/02/04	0.093	1	11	2.0	7.9	14.3	7.5	15.0
03/09/04	0.083	1	12	1.3	9.9	14.4	9.6	15.1
03/16/04	0.078[a]	4	51	8	40	65	39	68
03/23/04	0.100	5	50	9	38	68	36	71
03/30/04	0.021	3	143	48	86	215	81	258
04/06/04	0.021	1	48	19	29	86	27	108
04/13/04	0.022	5	230	67	150	332	136	374

Table 11 (Cont.)

04/20/04	0.078[a]	9	115	18	90	147	85	158
04/27/04	0.078[a]	8	102	17	79	135	76	140
05/04/04	0.078[a]	32	409	62	321	524	308	542
05/11/04	0.078[a]	55	704	113	551	931	530	1,000
05/18/04	0.078[a]	24	307	49	240	393	227	421
05/25/04	0.078[a]	13	166	26	130	213	123	228
06/10/04	0.078[a]	6	77	12	60	98	58	105
06/08/04	0.078[a]	18	230	37	180	295	173	316
06/15/04	0.078[a]	6	77	12	60	98	58	102
06/22/04	0.078[a]	3	38	6	30	49	29	53
Totals	**---**	***194***	***2,770***	***170***	***2,512***	***3,057***	***2,455***	***3,142***

[a] Season average efficiency based on valid trials conducted January 14 through April 16, 2004.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SE's were calculated using bootstrapped values.

Table 12. Summary of spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead juvenile passage estimates at the Lower Battle Creek rotary screw trap including run designation, brood year, original CAMP estimate, current estimate (N), and the 90 and/or 95% confidence intervals for the current estimates. Shaded rows indicated estimates for the current reporting period.

Run	Brood Year	Original CAMP Estimate[c]	Current Estimate	90% Confidence Interval		95% Confidence Interval	
				Lower CI	Upper CI	Lower CI	Upper CI
Spring	1998	---	---	---	---	---	---
	1999	---	---	---	---	---	---
	2000	---	---	---	---	---	---
	2001	---	8,978	8,113	10,002	8,003	10,160
	2002	---	2,315	2,078	2,628	2,037	2,713
	2003	---	14,809	13,139	16,632	12,809	16,922
Fall	1998	4,909,700	4,897,569	---	---	4,238,511	5,732,692
	1999	16,697,610	18,708,768	---	---	14,103,348	26,372,818
	2000-partial[a]	---	5,451,599	---	---	4,270,908	7,182,598
	2001	---	4,040,686	3,721,942	4,413,372	3,676,854	4,522,353
	2002	---	581,677	542,513	625,834	537,926	636,193
	2003	---	3,143,957	2,863,640	3,492,043	2,821,952	3,598,515
Late-Fall	1999	113,684	86,305	---	---	72,258	98,591
	2000	99,803	86,940	---	---	73,793	106,967
	2001	---	---	---	---	---	---
	2002	---	59,183	50,087	72,672	48,738	75,194
	2003	---	31,538	29,371	34,371	29,126	34,580
	2004	---	23,193	20,497	26,193	20,103	26,875
RBT/Steelhead	1999[b]	---	7,057	---	---	6,196	8,368
	2000[b]	---	8,417	---	---	7,699	9,608
	2001	---	---	---	---	---	---
	2002 (1+)[d]	---	647	583	725	574	735
	2002 (YOY)	---	8,153	7,261	9,255	7,096	9,576
	2003 (1+)[d]	---	577	540	622	633	632
	2003 (YOY)	---	2,313	2,164	2,479	2,187	2,520
	2004 (1+)[d]	---	471	421	526	413	538
	2004 (YOY)	---	1,144	1,031	1,268	1,013	1,301

[a] This passage estimate is not a complete brood year as the trap was not fished past February 9, 2001.

[b] These estimates are not brood years, rather two periods are summarized: October 9, 1998 to December 26, 1999 and December 27, 1999 to February 9, 2001.

[c] The original CAMP estimates cover the period January 1 through December 31; therefore, they may not include the entire brood year, and late-fall estimates may include fish from two brood years.

[d] Passage estimates for age 1+ trout are not for the current brood year, but rather a mixture of previous year-classes captured during the reporting period.

Table 13. Summary of fall, late-fall, and spring Chinook salmon and rainbow trout/steelhead juvenile passage estimates at the Upper Battle Creek rotary screw traps including run designation, brood year, original CAMP estimate, current estimate (N), and the 90 and/or 95% confidence intervals for the current estimates. Shaded rows indicated estimates for the current reporting period.

				90% Confidence Interval		95% Confidence Interval	
Run	Brood Year	Original CAMP Estimate[c]	Current Estimate	Lower CI	Upper CI	Lower CI	Upper CI
Spring	1998	4,589	4,791	---	---	3,949	6,204
	1999	10,061	6,233	---	---	5,225	7,678
	2000	---	---	---	---	---	---
	2001	---	482	389	615	377	644
	2002	---	926	810	1,070	798	1,102
	2003	---	11,264	9,251	14,026	8,973	14,709
Fall	1998	1,466,274	1,193,916	---	---	996,588	1,546,430
	1999	211,662	239,152	---	---	202,274	291,194
	2000-partial[a]	---	43,850	---	---	37,476	54,567
	2001	---	20,920	18,642	24,337	18,195	25,143
	2002	---	17,754	15,883	19,731	15,648	20,244
	2003	---	141,393	128,557	155,900	127,193	160,251
Late-Fall	1999	---	212	177	261	170	273
	2000	---	50	36	70	35	78
	2001	---	---	---	---	---	---
	2002	---	7,628	5,950	9,969	5,753	10,604
	2003	---	6,673	5,835	7,409	5,679	7,631
	2004	---	1,145	809	1,732	768	1,968
RBT/Steelhead	1999[b]	---	10,388	---	---	8,810	12,976
	2000[b]	---	25,710	---	---	21,865	30,713
	2001	---	---	---	---	---	---
	2002 (1+)[d]	---	1,348	1,201	1,607	1,170	1,666
	2002 (YOY)	---	24,740	21,034	29,565	20,454	31,426
	2003 (1+)[d]	---	592	522	671	511	698
	2003 (YOY)	---	7,087	6,441	7,769	6,349	7,978
	2004 (1+)	---	826	753	903	741	917
	2004 (YOY)	---	2,770	2,512	3,057	2,455	3,142

[a] This passage estimate is not a complete brood year as the trap was not fished past February 9, 2001.

[b] These estimates are not brood years, rather two periods are summarized: October 9, 1998 to December 26, 1999 and December 27, 1999 to February 9, 2001.

[c] The original CAMP estimates cover the period January 1 through December 31; therefore, they may not include the entire brood year, and late-fall estimates may include fish from two brood years.

[d] Passage estimates for age 1+ fish are not for the current brood year, but rather a mixture of previous year-classes captured during the reporting period.

Figures

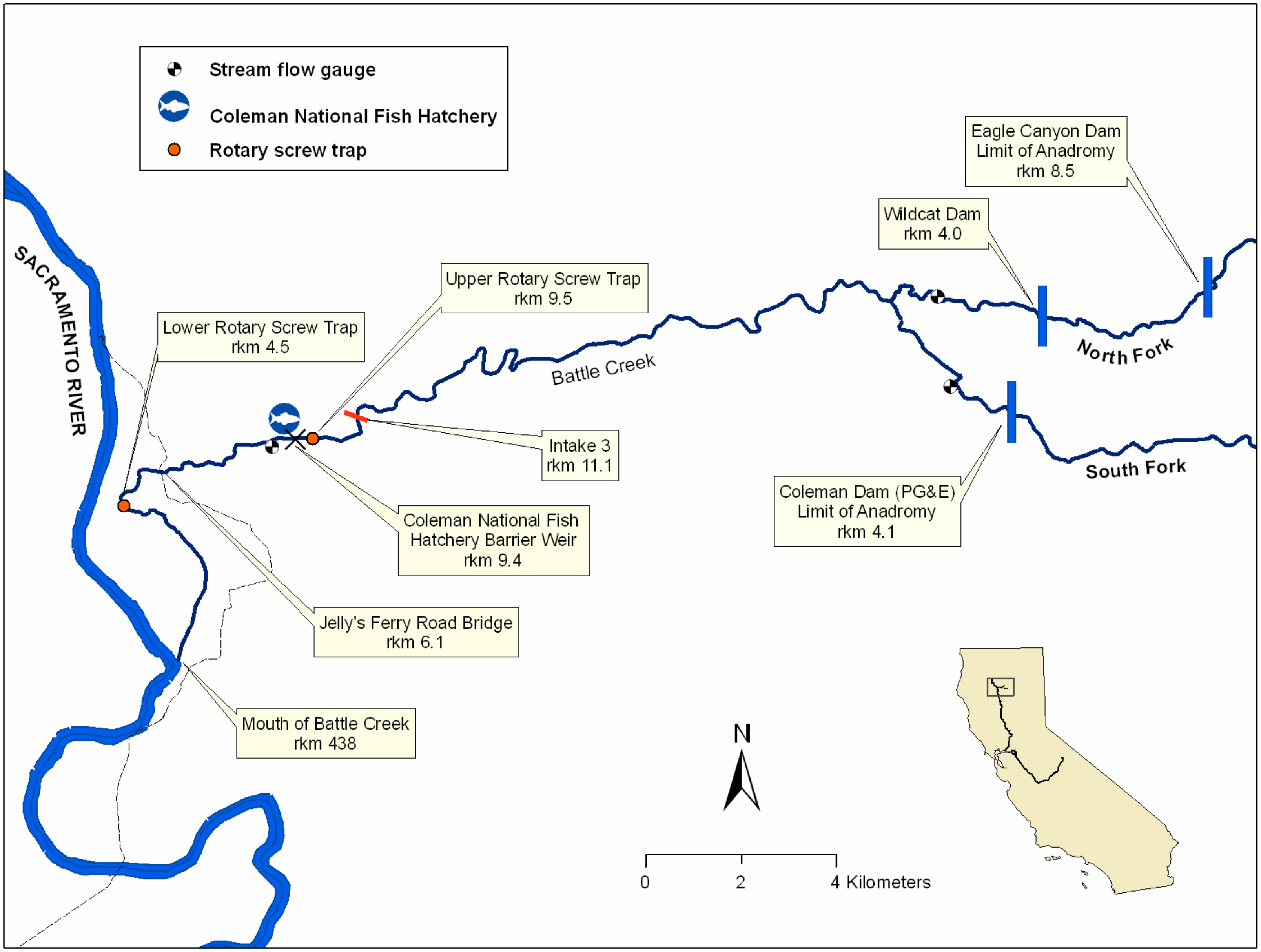

Figure 1. Map of Battle Creek depicting the location of USFWS' rotary screw traps and other important features.

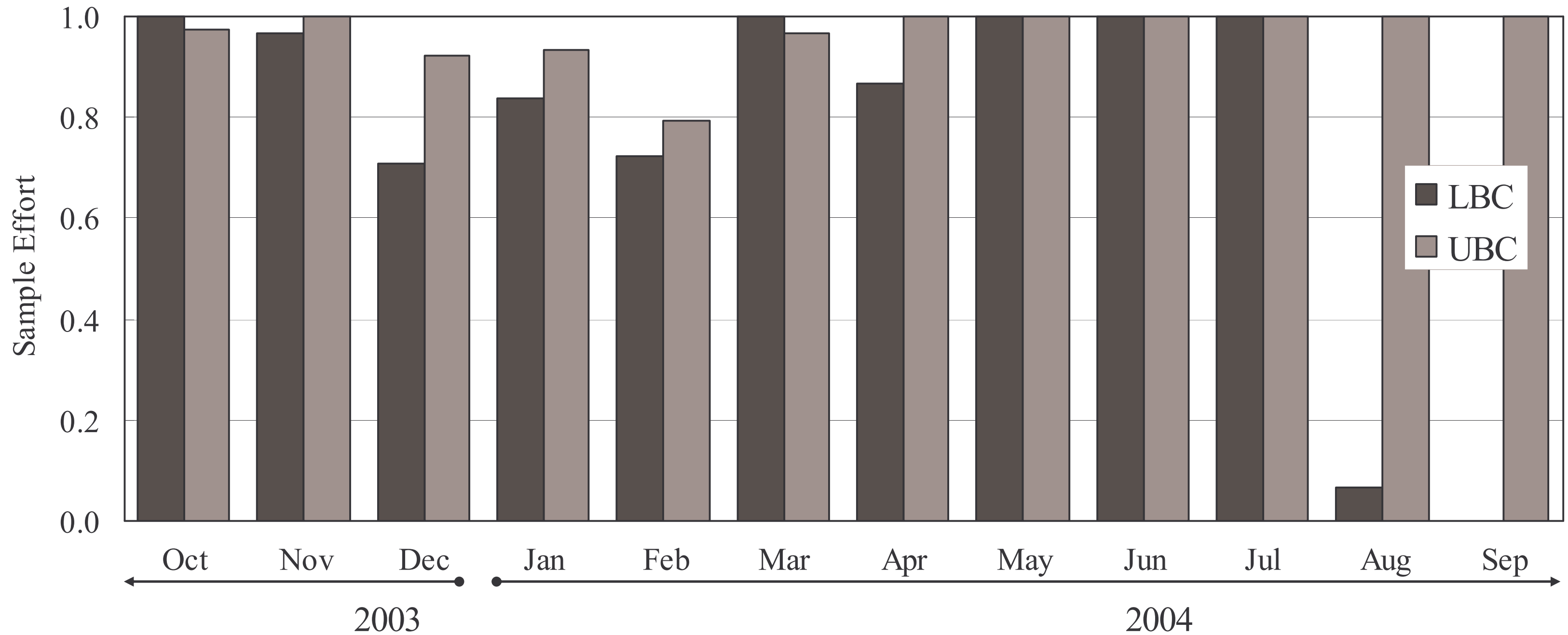

Figure 2. Sampling effort summarized as the proportion (range: 0 to 1) of days fished each month at the Lower and Upper Battle Creek rotary screw traps from October 1, 2003 to September 30, 2004. The LBC trap was not operated during most of August and all of September 2004.

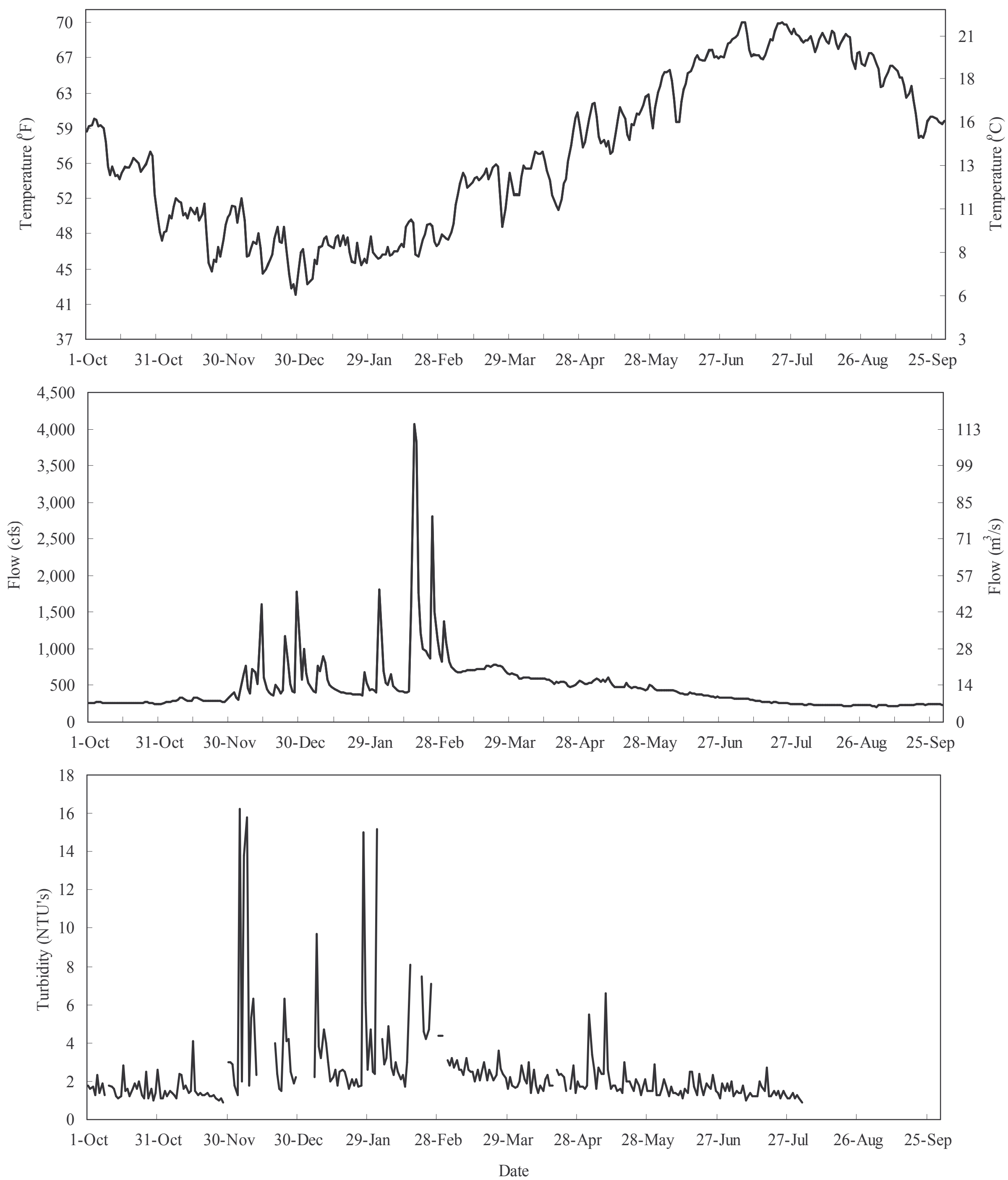

Figure 3. Mean daily temperature (ºC and ºF), mean daily flows (m^3/s and cfs), and turbidity (NTU's) at the Lower Battle Creek rotary screw trap from October 1, 2003 through September 30, 2004.

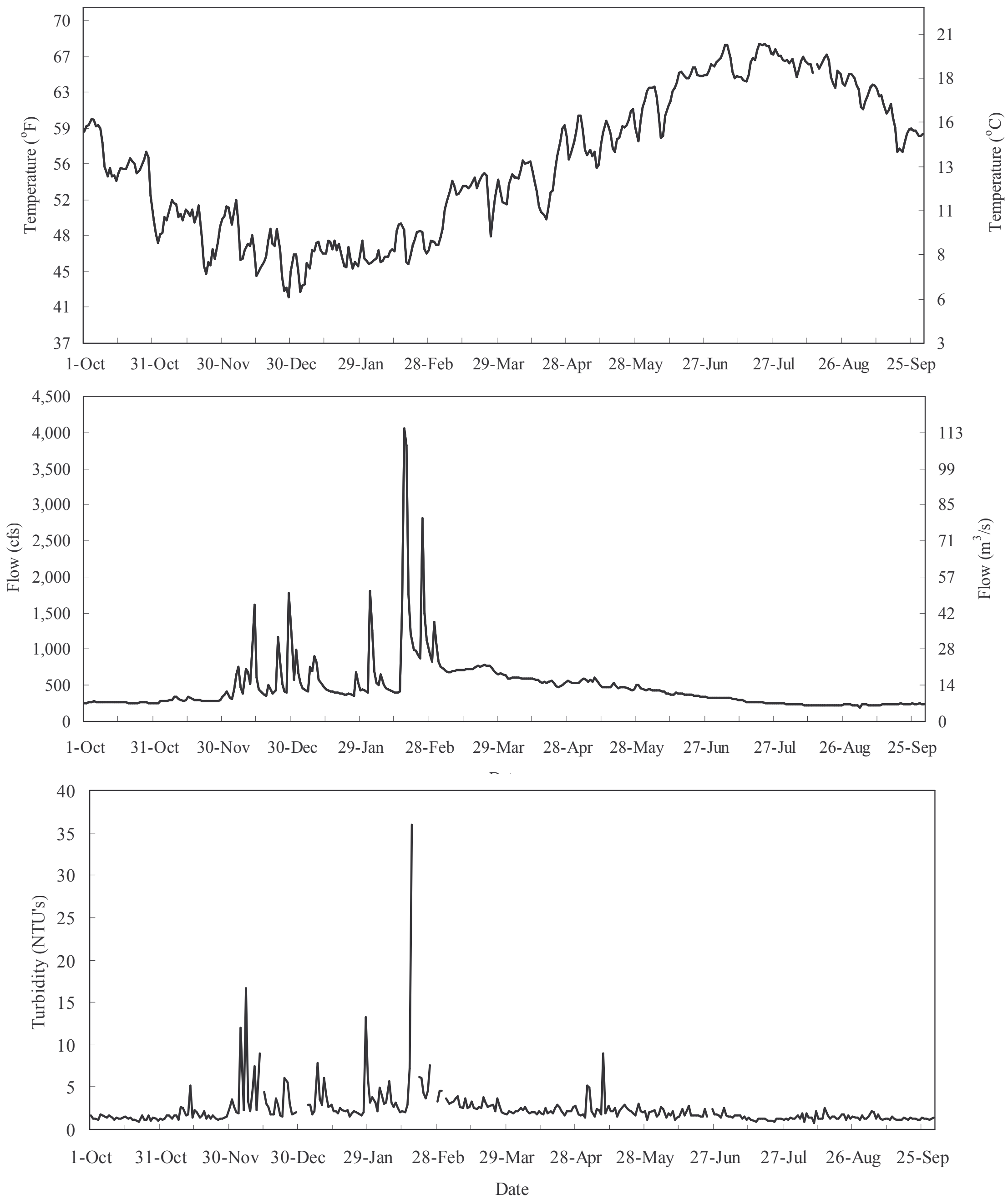

Figure 4. Mean daily temperature (ºC and ºF), turbidity (NTU's), and mean daily flows (m^3/s and cfs), at the Upper Battle Creek rotary screw trap from October 1, 2003 through September 30, 2004.

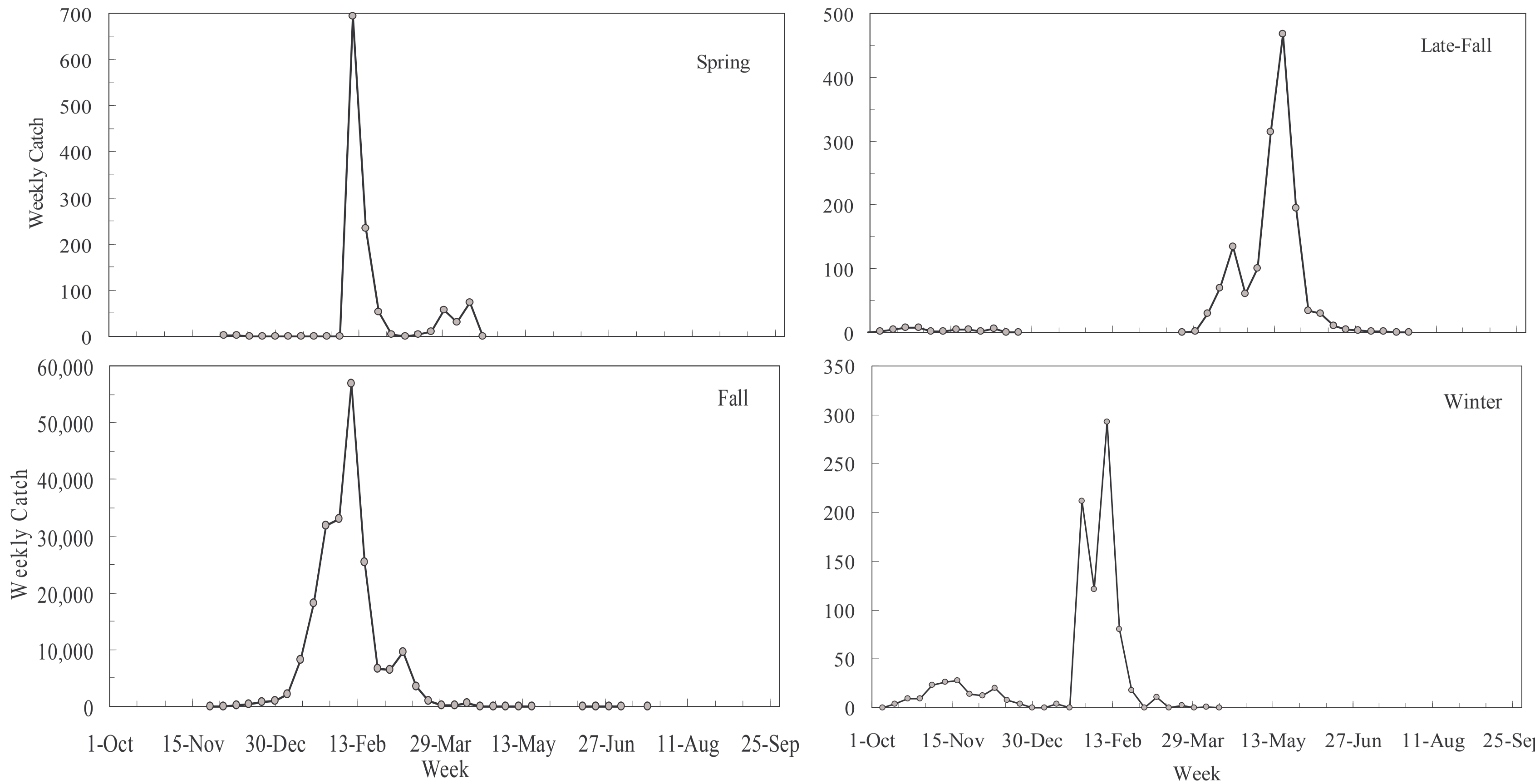

Figure 5. Weekly catch of spring, fall, late-fall, and winter Chinook salmon captured at the Lower Battle Creek rotary screw trap from October 1, 2003 to August 2, 2004. Run designation was assigned using the length-at-date criteria developed for the Sacramento River (Greene 1992).

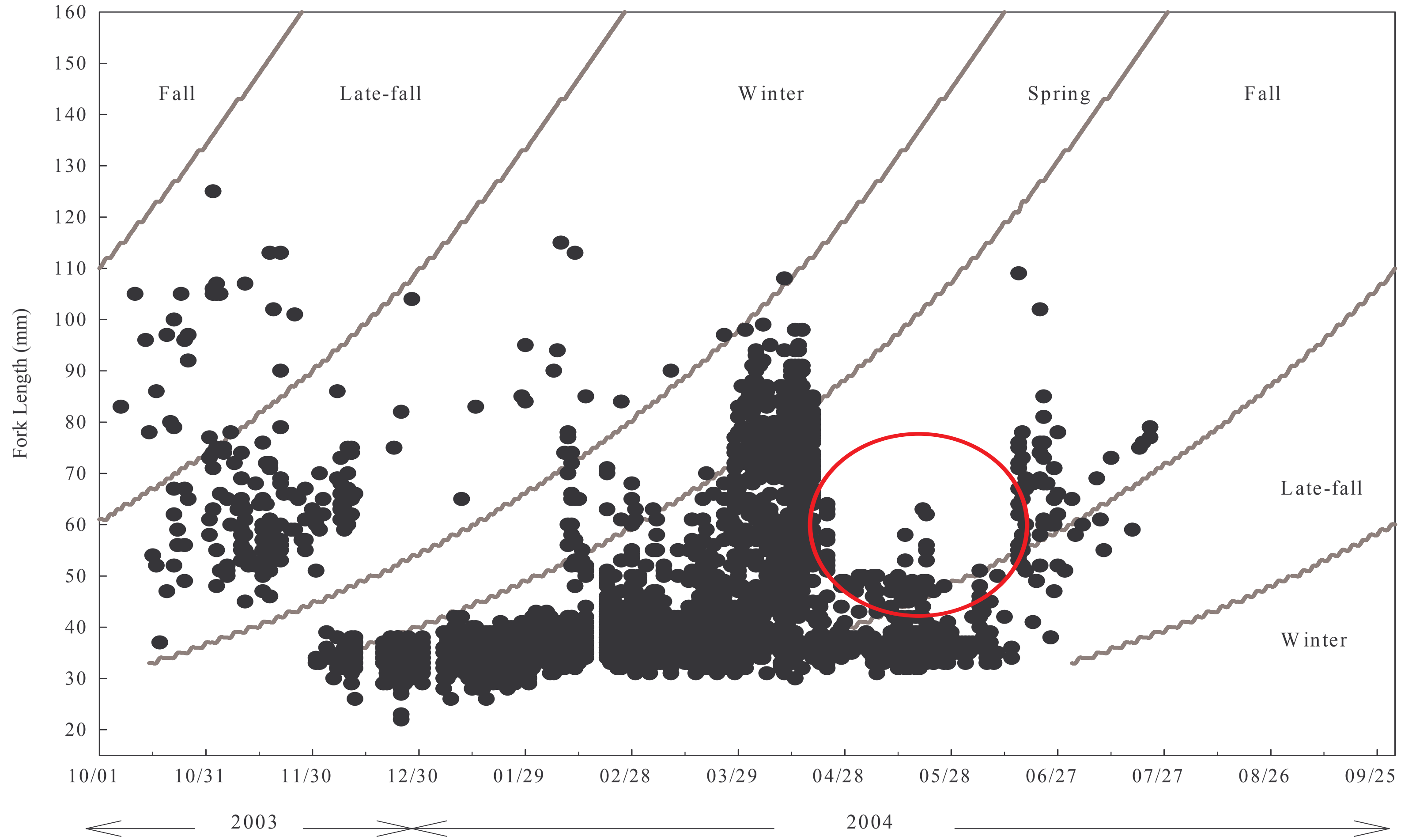

Figure 6. Fork length (mm) distribution by date and run for Chinook salmon captured at the Lower Battle Creek rotary screw trap from October 1, 2003 to September 30, 2004. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992). The red circle indicates the period when unmarked hatchery fall Chinook salmon were released. Most Chinook ≥45 mm were not included as they were likely hatchery fish.

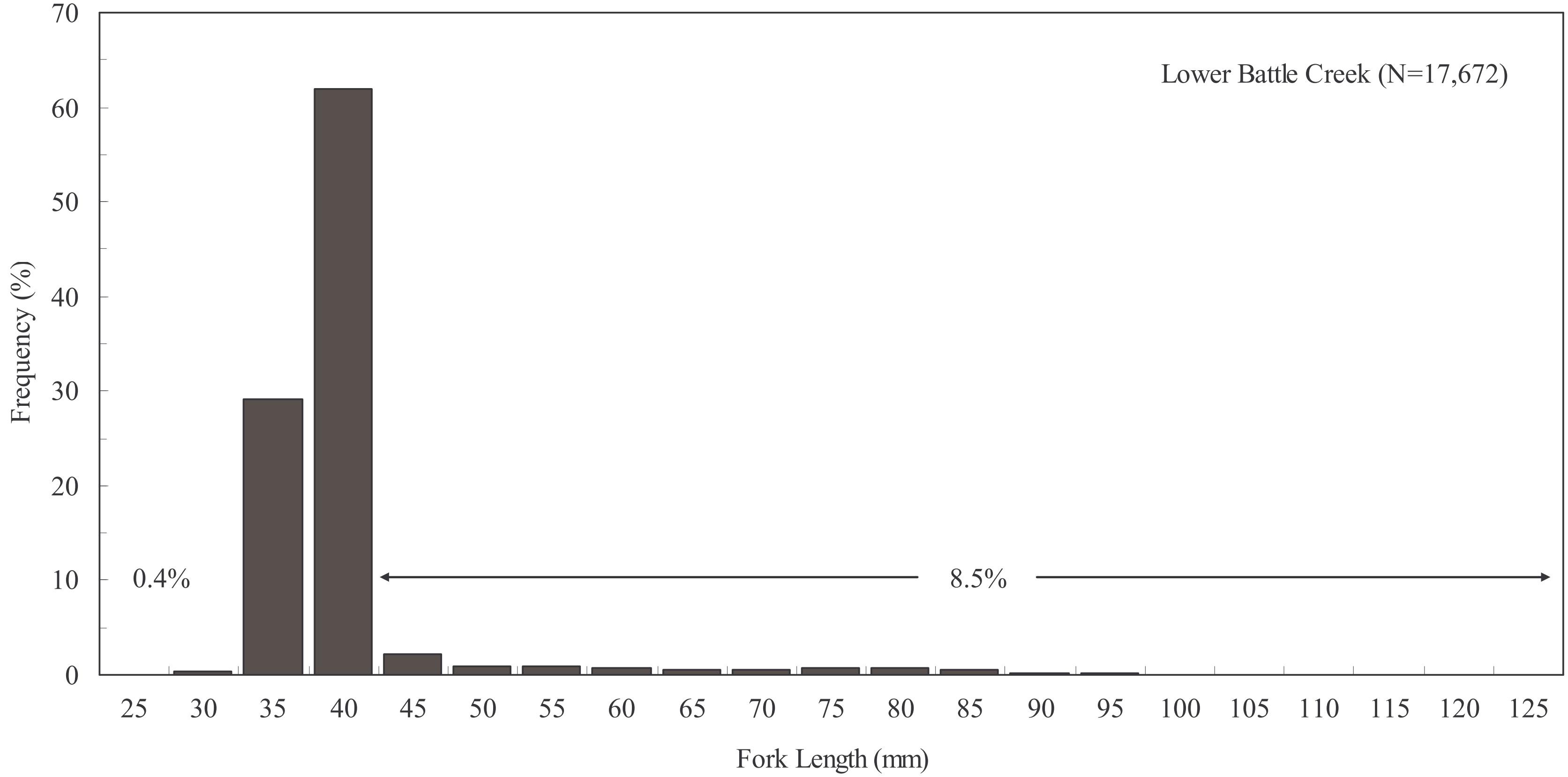

Figure 7. Length frequency (%) for all runs of Chinook salmon measured at the Lower Battle Creek rotary screw trap (LBC) during October 1, 2003 through September 30, 2004. Fork length axis labels indicate the upper limit of a 5-mm length range.

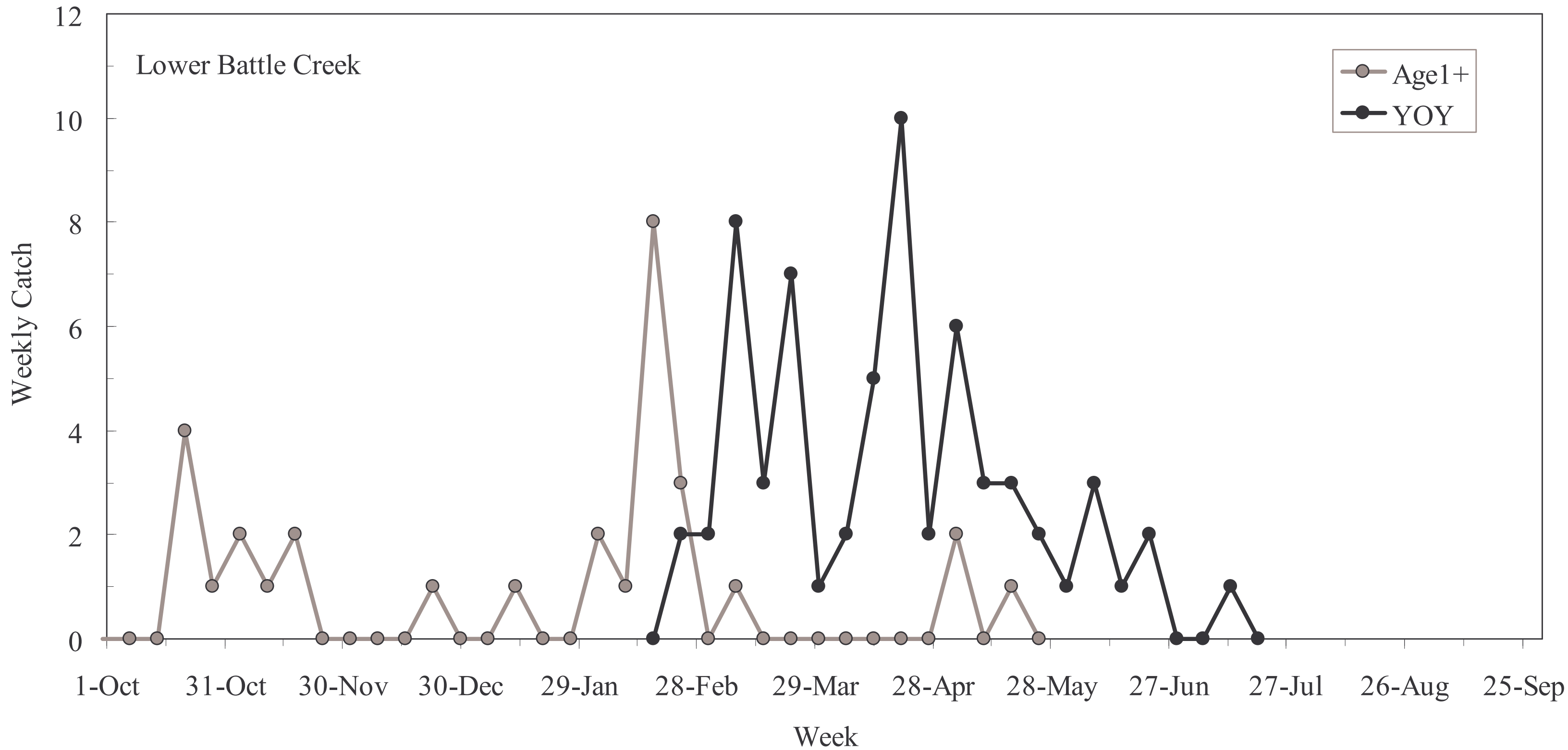

Figure 8. Weekly catch of age 1+ and “young-of-the-year” (YOY) rainbow trout/steelhead at the Lower Battle Creek rotary screw trap from October 1, 2003 to September 30, 2004. Age 1+ trout includes individuals from all age-classes other than brood year 2004.

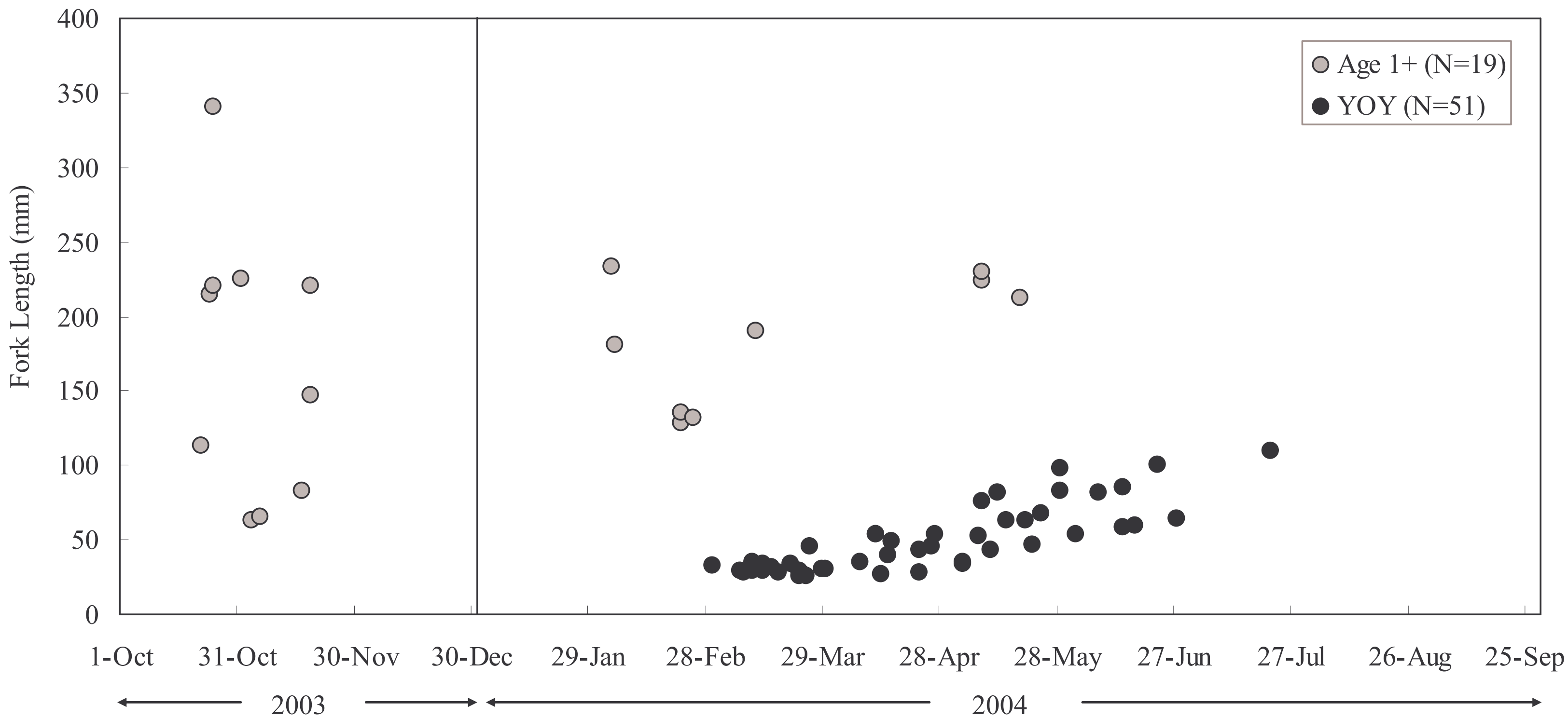

Figure 9. Fork length (mm) distribution for age 1+ and young-of-the-year (YOY) rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during October 1, 2003 through September 30, 2004. Age 1+ fish may include individuals from more than one year class.

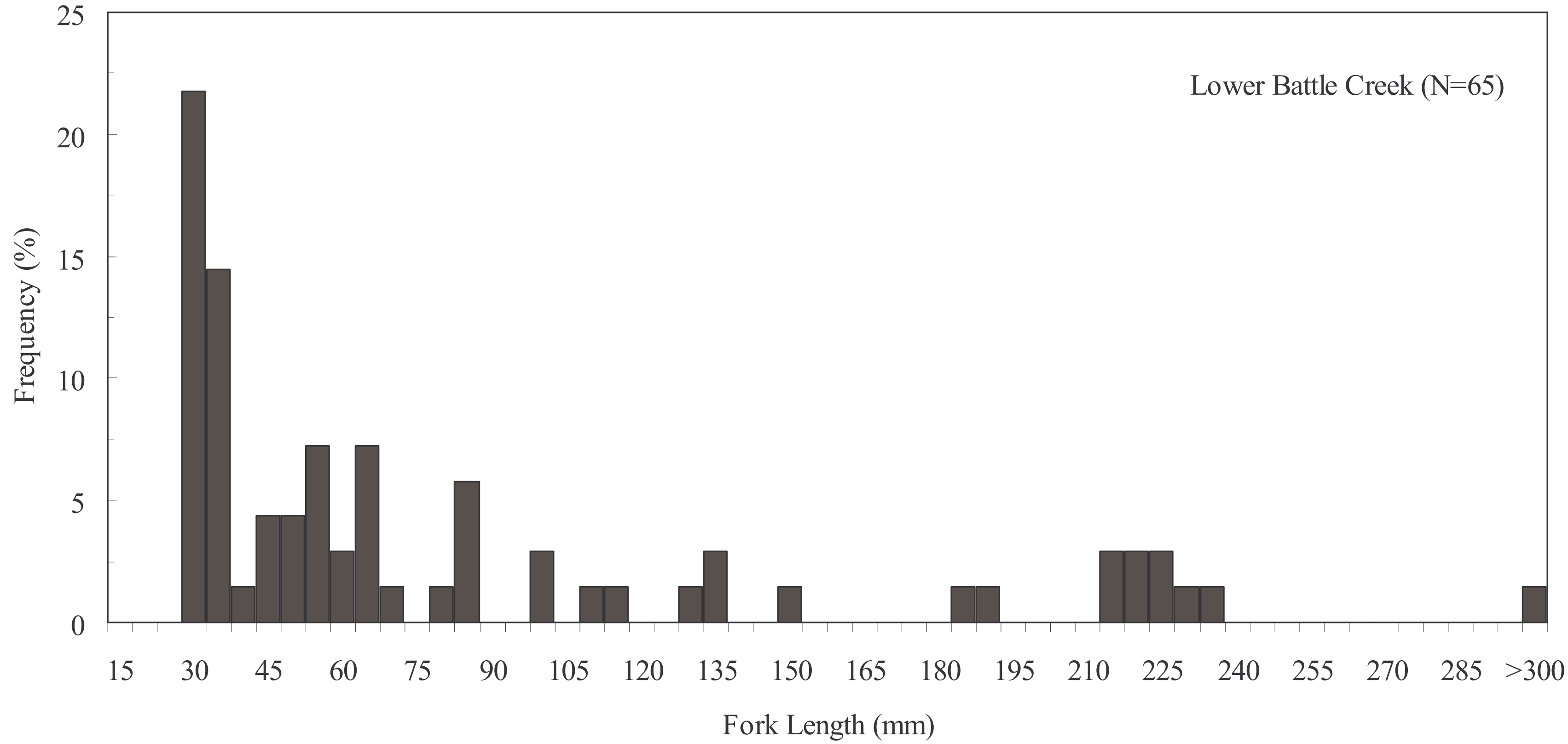

Figure 10. Fork length frequency (%) for rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during October 1, 2003 through September 30, 2004. Fork axis labels indicate the upper limit of a 5-mm length range.

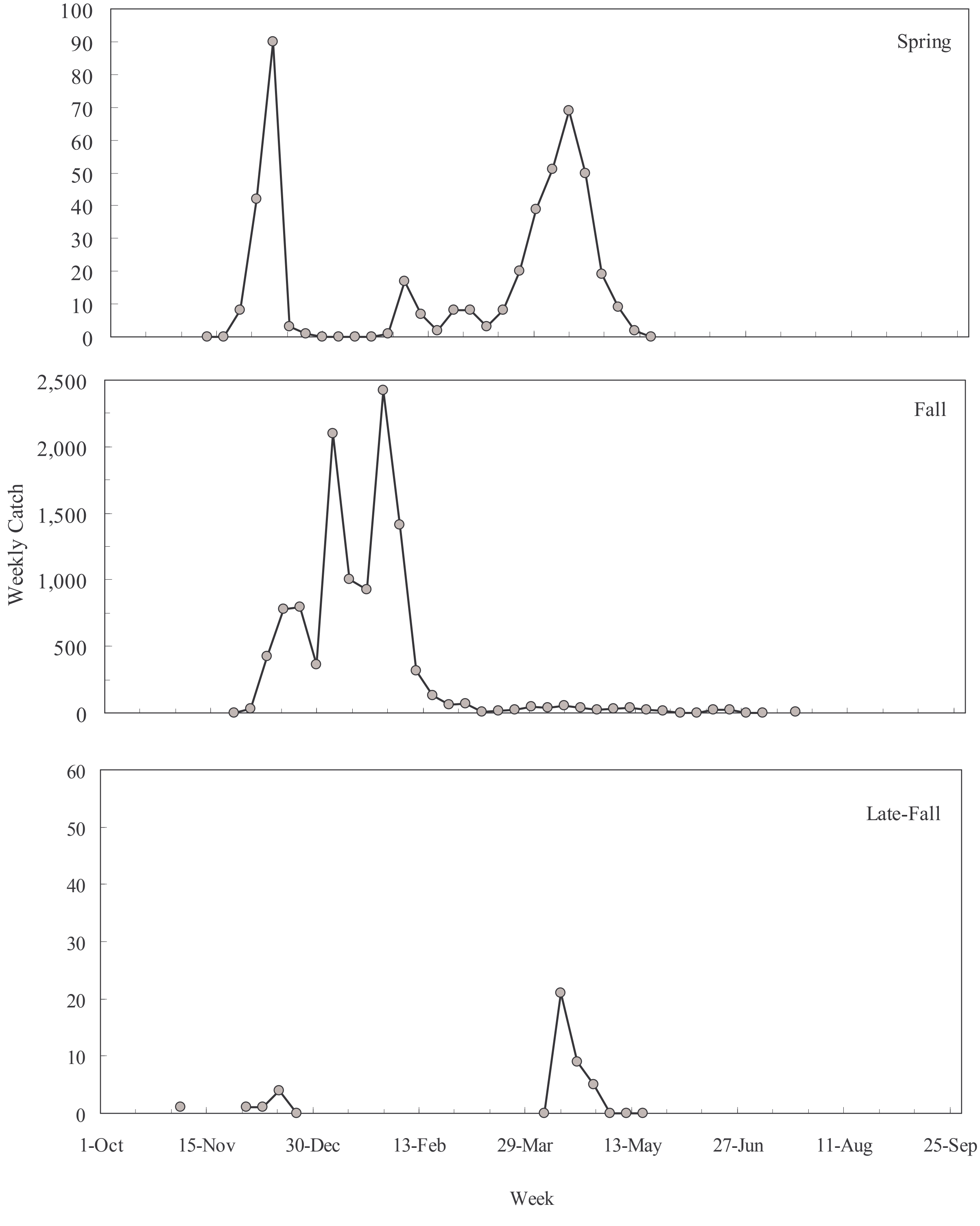

Figure 11. Weekly catch of spring, fall, and late-fall Chinook salmon captured at the Upper Battle Creek rotary screw trap from October 1, 2003 to September 30, 2004. Only one winter Chinook salmon was captured; therefore it was not displayed graphically. Run designation was assigned using the length-at-date criteria developed for the Sacramento River (Greene 1992).

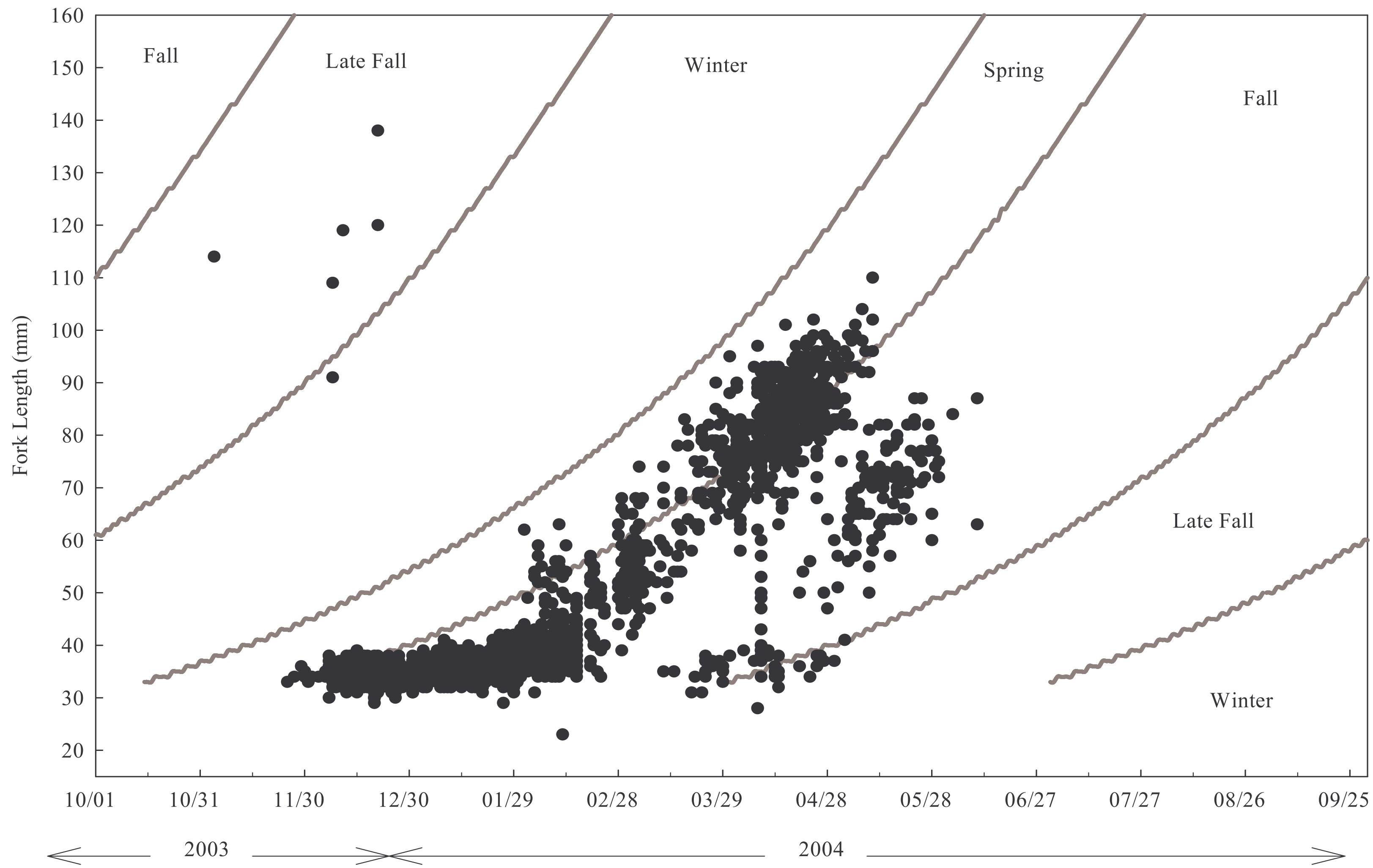

Figure 12. Fork length (mm) distribution by date and run for Chinook salmon captured at the Upper Battle Creek rotary screw trap from October 1, 2003 to September 30, 2004. Spline curves represent the maximum fork lengths expected for each run by date, based on criteria developed by the California Department of Water Resources (Greene 1992).

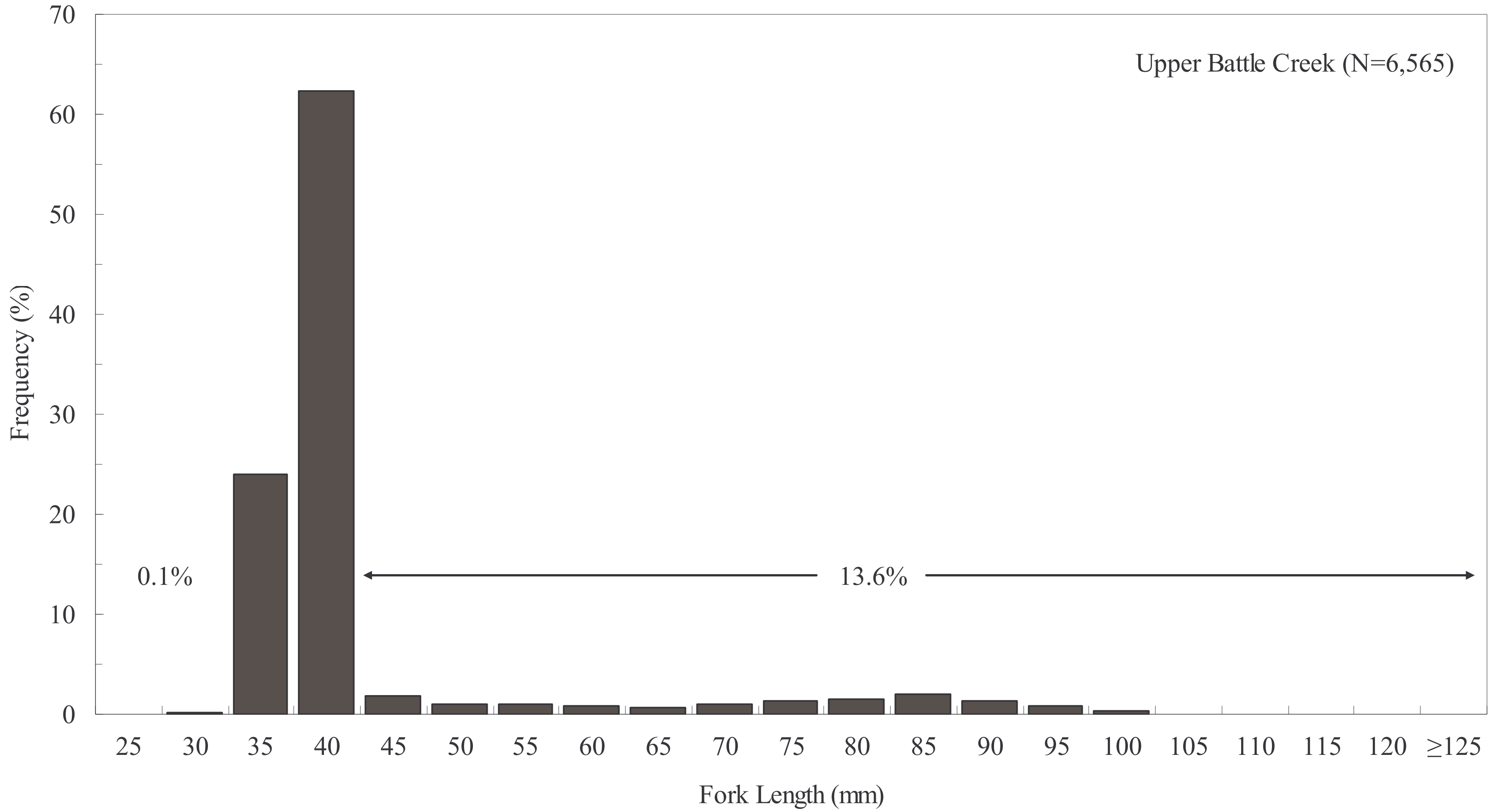

Figure 13. Length frequency (%) for all runs of Chinook salmon measured at the Upper Battle Creek rotary screw trap (UBC) during October 1, 2003 through September 30, 2004. Fork length axis labels indicate the upper limit of a 5-mm length range.

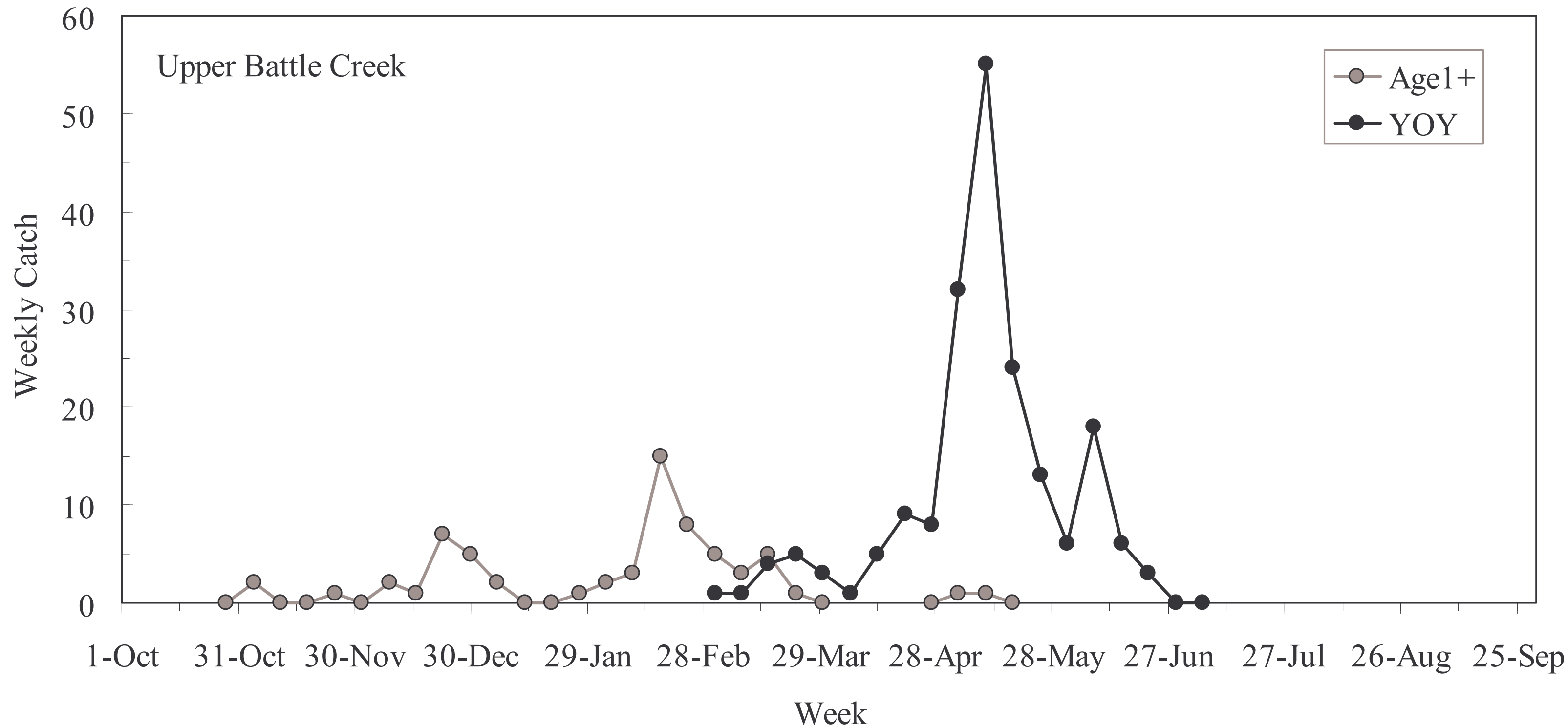

Figure 14. Weekly catch of Age 1+ and “young-of-the-year” (YOY) rainbow trout/steelhead at the Upper Battle Creek rotary screw trap from October 1, 2003 to September 30, 2004. Age 1+ trout includes individuals from all age-classes other than brood year 2004.

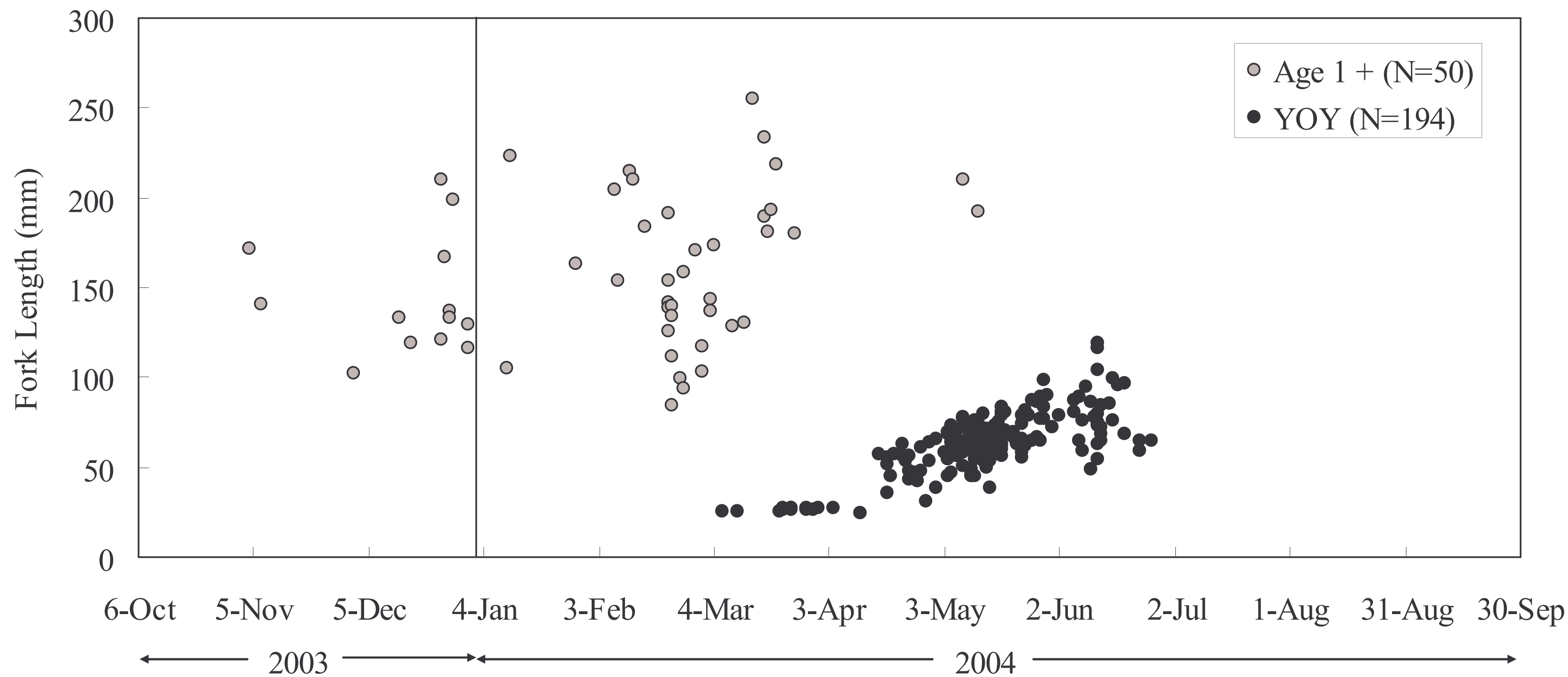

Figure 15. Fork length (mm) distribution by date for age 1+ and young-of-the-year rainbow trout/steelhead measured at the Upper Battle Creek rotary screw trap during October 1, 2003 through September 30, 2004. Age 1+ fish may include individuals from more than one year class.

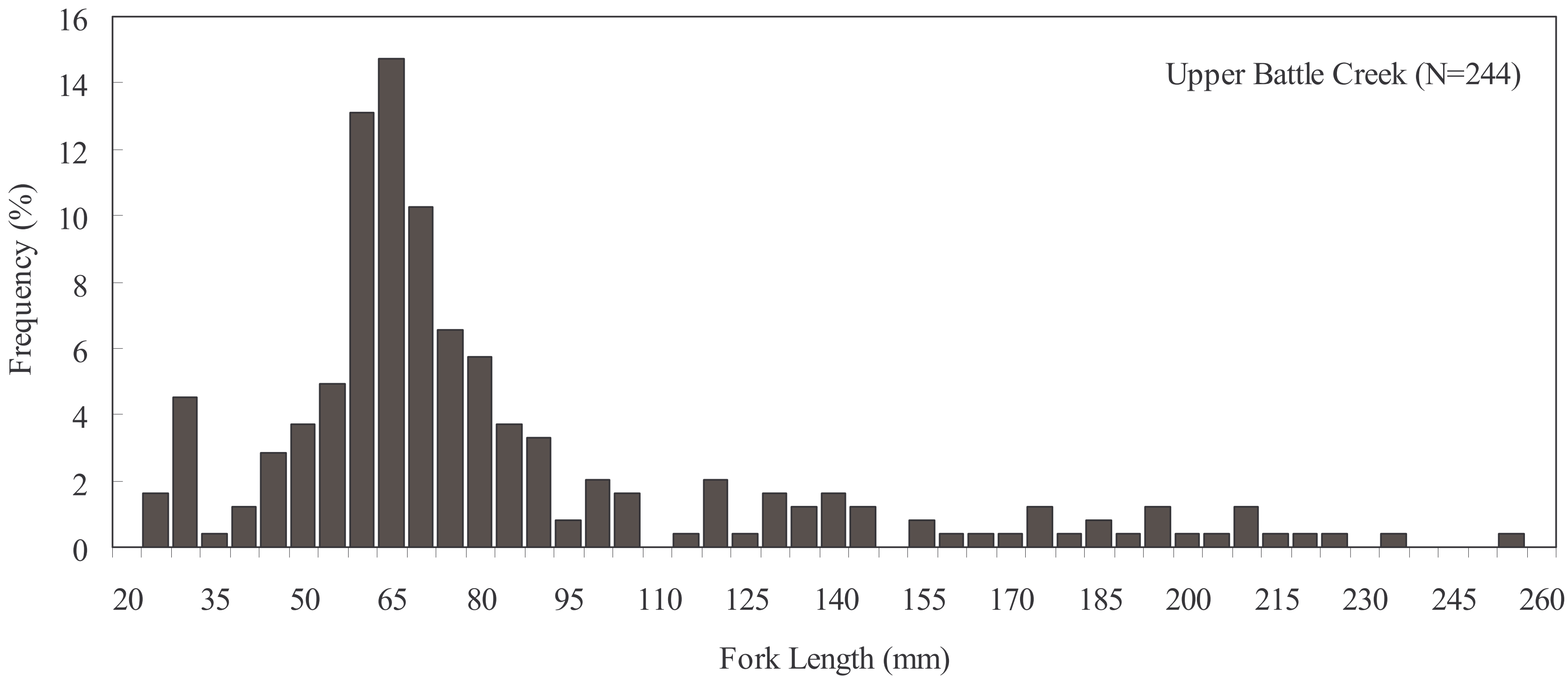

Figure 16. Fork length frequency (%) for rainbow trout/steelhead sampled at the Upper Battle Creek rotary screw trap during October 1, 2003 through September 30, 2004. Fork axis labels indicate the upper limit of a 5-mm length range.

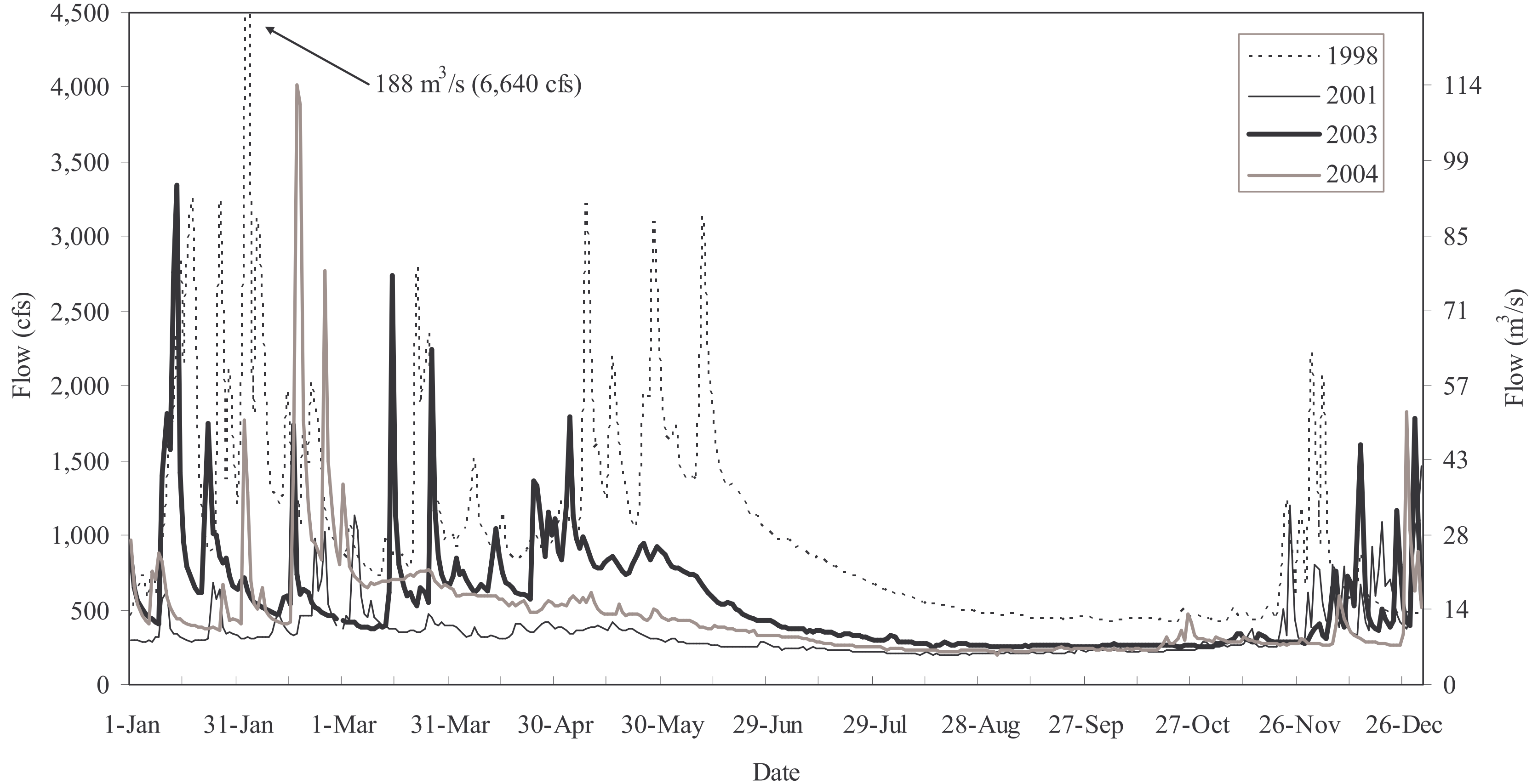

Figure 17. Mean daily flows (m^3/s) recorded at the U. S. Geological Survey gauging station (BAT-#11376550) located below the Coleman National Fish Hatchery barrier weir, January 1, 2003 to December 31, 2004. Flows for the wettest (1998) and driest (2001) years of sampling are included for comparison.

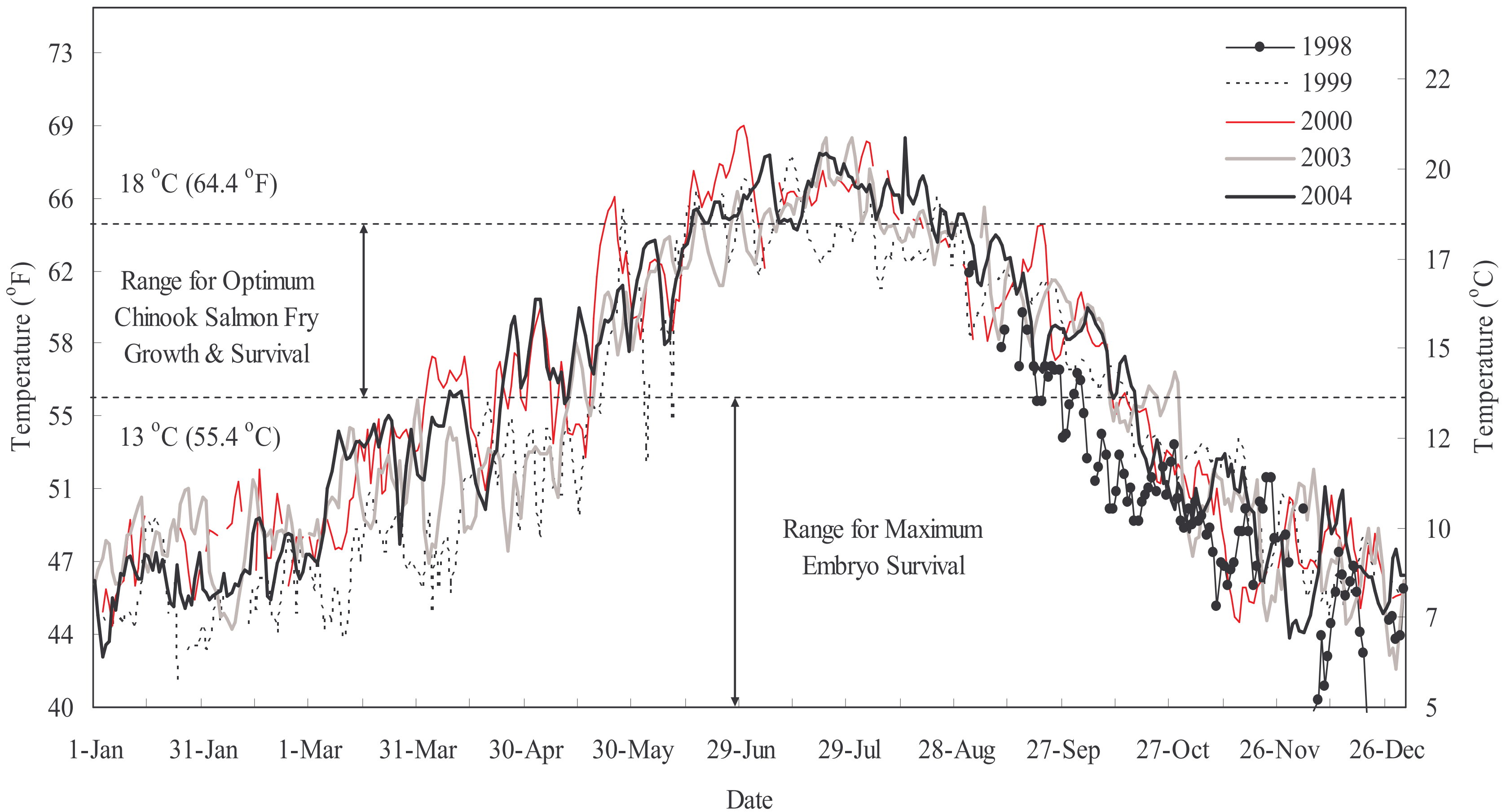

Figure 18. Mean daily water temperatures at the Upper Battle Creek rotary screw trap for 1998-2000 and 2003 through 2004. In 1998, data was not available prior to trap operation. Temperatures for 1998 to 2000 were included to allow comparisons between the current sample period (October 1, 2003 to September 30, 2004) and years when temperatures in general were the coolest and warmest during monitoring. Temperature ranges for optimum Chinook salmon embryo survival and fry growth and survival are included.

Appendix

Appendix 1. Summary of days the Lower Battle Creek rotary screw trap did not fish during the report period (October 1, 2003 to September 30, 2004), including sample dates, hours fished, and reason for not fishing.

Sample Dates	Hours Fished (approx)	Reason
	2003	
November 29	0	Late-fall Chinook Hatchery Release
December 13 & 14	0	High Flows – Trap Sunk
December 15-19	0	Trap Repair
December 29 & 30	4	High Flows
	2004	
January 1 - 5	0	Late-fall Chinook Hatchery Release
February 3	0	High Flows
February 16-20	0	High Flows
February 26 & 27	0	High Flows
March 2	0	High Flows
April 17 & 18	0	Fall Chinook Hatchery Release
April 24 & 25	0	Fall Chinook Hatchery Release
August 3 to September 30	0	Little or No Salmonid Catch

Appendix 2. Summary of days the Upper Battle Creek rotary screw trap did not fish during the report period (October 1, 2003 to September 30, 2004), including sample dates, hours fished, and reason for not fishing.

Sample Dates	Hours Fished (approx.)	Reason
	2003	
October 29	4	Cone not rotating - debris
December 14	0	High Flows – Trap Sunk
December 29 and 30	13	High Flows
	2004	
January 1 & 2	0	High Flows
February 3	0	High Flows
February 17-19	0	High Flows
February 26 & 27	0	High Flows
March 2	0	High Flows